VOL. 16 - DOC. 130

WORLD COMMISSION ON ENVIRONMENT AND DEVELOPMENT

SEVENTH MEETING
Moscow, U.S.S.R.
December 6 - 12, 1986

WCED/86/31

TO: All Members of the World Commission on Environment and Development

FROM: Jim MacNeill
Secretary General

DATE: 25 November, 1986

RE: Draft Chapter 6 of the Final Report

Please find attached a draft of Chapter 6, provisionally entitled "Energy: the Power to Develop".

The present draft has been prepared by our Special Advisor, Professor Gordon Goodman, and reflects an attempt to incorporate the changes in emphasis and substance suggested at the last meeting in Harare. In form, an attempt has been made to shorten the Chapter by eliminating redundancies, reducing overlap with other Chapters and cutting the final section on institutional change. Specific recommendations have been placed in boxes within and at the end of the section that provides the analysis which justifies them. Many references have been added to the text, but due to the pressure of time, they have not been included in this draft. Full citations will be available for the next meeting.

As requested in Harare, Professor Goodman has added a number of tables and text figures, the inclusion of which in the next draft will need to be considered both from a substantive and editorial point of view.

The present draft has not been edited by Linda Starke, and selection of quotations from the Public Hearings has not been made yet, and is therefore not reflected in the present text.

ACTION REQUIRED: For Discussion and Approval

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CHAPTER 6

ENERGY: THE POWER TO DEVELOP

CHAPTER 6

ENERGY: THE POWER TO DEVELOP

I. ENERGY CHOICES FOR SURVIVAL AND DEVELOPMENT

1. Before the mid-1970s, energy was largely taken for granted. Only after the oil-price rises of 1973-4 did it become universally recognized as a crucial factor in producing the goods and services required to sustain human communities. Adequate heat and power are needed not only to ensure the future orderly development of societies, but also to secure their current day-to-day survival . Since no nation can hope to develop unless it is already surviving as a reasonably stable entity, it is very important not to neglect present-day energy provision as the first essential step in planning supplies for the future. In economies where traditional energy such as wood, dung and muscle-power are still dominant, this priority of energy for the daily survival of the vast majority of people may tend to be overlooked in the drive towards modernized urban-industrial development.

2. When planning for the future, every country will try to promote forms of development that are as far as possible, sustainable in perpetuity. Energy to fuel this development may however be derived from sources that are non-renewable and effectively finite (unsustainable). Fossil fuels such as natural gas, oil, coal, and peat or

conventional nuclear power come into this category. By contrast, there are sources which are either renewable or extremely large and effectively infinite (Table 1). Geothermal sources, direct solar energy (trapped by photovoltaic cells, flat-plate and other thermal collectors), or indirect solar energy are in this category. Examples of indirect solar energy are wind, waves, tides, falling water, ocean-thermal gradients and woody plant material or animal dung (biomass) as well as human and animal muscle-power. In future, hydrogen fuel, nuclear breeder- and fusion-reactors will also be considered for adoption. In theory at least, all of these sources can contribute to the future energy mix worldwide. They each have their own economic, health and environmental costs and benefits. But perhaps it is axiomatic that wherever feasible, societies will tend to develop their long-term dependence on those energy sources which they perceive as: most economic and readily available; safe; environmentally benign and in particular, sustainable. It is not possible to formulate one uniform set of criteria for this selection process because every society will wish to choose in accordance with its prevailing socio-economic, political and cultural background as well as its locally available energy sources. It is, however, very important that all the basic factors conditioning economic costs, health- and environment-safety, availability and sustainability are made clear so that the ultimate choice of energy mix is made under conditions of minimal uncertainty.

3. There is no time to be lost in doing this because the energy supply and consumption patterns of today are already influencing those which will prevail to the year 2000 and beyond. The same is true, of course, of current patterns of population growth, urbanization, industrialization, agriculture and transport. But growth in population, urbanization and industrial

activity directly places an additional burden on energy demand. Moreover, intensification of agriculture and transport, driven by these three closely linked factors, imposes extra energy loadings which act as further multipliers to demand. In short, energy needs are so sensitive to all the factors that normally accompany development that it is fairly natural to expect developmental problems to show up early in the energy sector. These usually take the form of harmful effects on the quality of life and the environment, caused by shortages of energy, especially in developing countries. Undesirable or harmful effects on health and the environment - via pollution - may also arise from the intensive use of energy, especially in cities and industrial regions. These problems connected with too little or too much energy are already overwhelmingly influential in that they can threaten the sustainable development of the countries and regions in which they are dominant.

II. UNSUSTAINABLE TRENDS

4. This is clearly true of the fuelwood crisis. According to an FAO study [7/,8/], in 1980, 1,300 million people lived in wood deficit areas (defined as areas where people can still satisfy their minimum domestic needs, but only through unsustainable over-cutting), and over 110 million in acute scarcity areas (where even through over-cutting people cannot satisfy minimum needs). The same study suggests that by the year 2000, about 3,000 million people will live in wood deficit and acute scarcity areas, often leading to great family hardship, increasing deforestation, erosion, land degradation and the diversion of plant and animal wastes from soil replenishment (Table 2).

5. A risk to sustainability also now seems to come from regional acidification of the environment in North America and, particularly, in Europe. The cryptic accumulation of damage by acidic and oxidizing substances from fossil fuel combustion has led to the widespread sterilization of lakes in Scandinavia[10/] and, to an impoverishment of forest soils in parts of Southern Sweden[11/]. Soil degeneration may also be the principalcause of the accelerating tree damage and death in some of Central Europe's forests and the consequent erosion, soil slippage and attendant flooding in steep sided valleys there.

6. Certain patterns of energy consumption may in future undermine sustainable development on a global scale. There is at present a scientific consensus worldwide that there now exists a "plausible and serious probability"[12/] of climate change, largely accelerated by the "greenhouse" effect of trace-gases emitted to the atmosphere. The most important of these trace-gases is carbon dioxide produced from the combustion of fossil fuels. Significant climate warming is now thought to be likely by the 2030's. It could subsequently disrupt ports and coastal cities by causing a rise in sea-levels. It may well influence rainfall, run-off and soil water-table regimes and even affect the geographical boundaries of crops, especially in mid-latitudes. Such impacts would place heavy pressures on national environmental security and may even unsettle regional political stability.

7. If global disruption caused by climate warming is still somewhat speculative, there is absolutely no doubt whatever about the severe problems worldwide caused by oil price rises during the last thirteen years. The fivefold increases in world oil prices initiated by OPEC during 1973 (Figure 1) raised the market price of one

TABLE 6-2

Populations Experiencing A Fuelwood Deficit
1980 and 2000 (in millions)

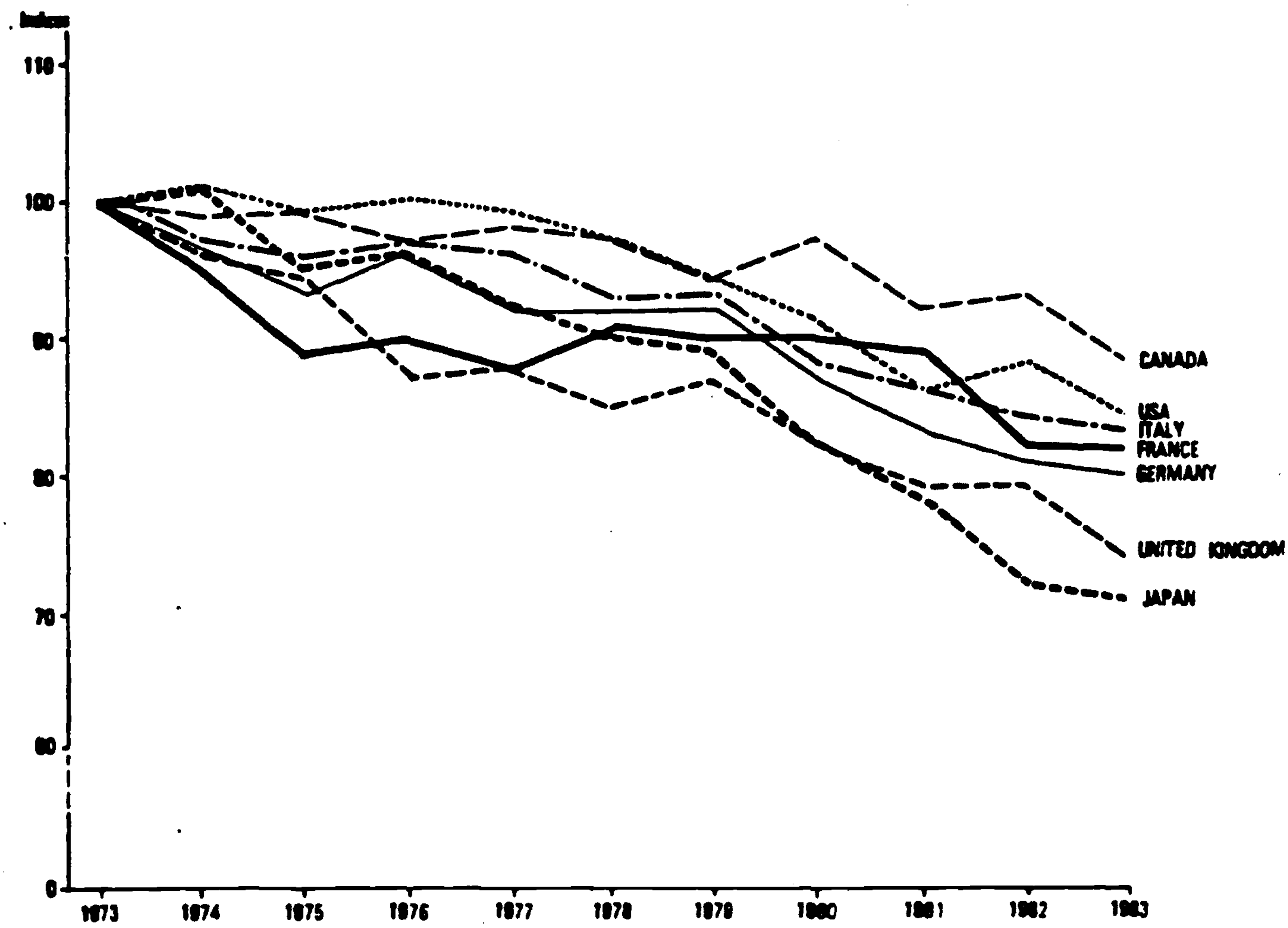
Year	1980				2000	
	Acute scarcity		Deficit		Acute Scarcity or Deficit	
Region	Total Population [a]	Rural Population [a]	Total Population	Rural Population	Total Population	Rural Population
Africa	55	49	146	131	535	464
Near East & North Africa	—	—	104	69	268	158
Asia and Pacif.	31	29	832	710	1671	1434
Latin America	26	18	201	143	512	342
Total	112	96	1283	1052	2986	2398

Note: a/ total population and rural population (total population less that of towns with more than 100,000 inhabitants) in zones whose fuelwood situation has been classified

Source: adapted from Food and Agriculture Organization, 1983[8] by WRI 1986[9]

FIGURE 6-2

Total Energy Required per Unit of Gross Domestic Product



Note : Indices (base 100 in 1973) are calculated from values of ratio

$$\frac{\text{Total Primary Energy Requirements}}{\text{Gross Domestic Product}}$$

Source: OECD - 1985 13/

year's oil output from 0.5 per cent to 2.5 per cent of gross world product. This produced a sharp downturn in economic growth rates and stagflation among many industrialized oil importers. It also arrested or even reversed development in many oil importing developing countries who became heavily indebted as the extra foreign exchange needed to buy oil was sucked out of their economies.

8. Much of the 2 per cent gross world product that was transferred to the oil exporters was lodged in North American banks, who had difficulty in finding borrowers among the many industrialized countries who were hit by the recession. Instead, large loans were readily arranged with those developing countries most badly affected by the oil price crisis. Relief for these came with the commodities boom of 1975 - 8; greatly improved terms of trade allowed many countries to enjoy a brief respite from their economic hardships. But when world oil prices rose again, effectively doubling during 1978-80 following the Iran-Iraq war, the picture was different. Tough financial policies by the industrialized countries largely contained the problem for them. The oil importing developing countries however were again hit hard, especially after the 1980-2 period, when commodity prices fell by 20-30 per cent. Their indebtedness became chronic and for many, debt-service costs and repayment problems have totally disrupted their economies since that time and caused anxiety among lenders in industrialized countries.

9. When this Commission was established in 1984, world oil prices stood at $28-$30 per barrel and what economic development was possible, was everywhere being planned on the assumption of a steady increase in the price of energy. The price collapse of 1986 saw oil fall to around US$10 per barrel in early April, followed by a

period of considerable market volatility. This has meant that, in terms of constant US dollars, oil fell back to around pre - 1973 price levels, which has had the opposite effect. It has led to economic dislocation among even the best-placed exporters and has stalled development particularly severely among those producers whose economies are heavily dependent on oil export revenues. Additionally, further lender anxiety developed when the poorer oil exporters now faced difficulties in repaying the large loans made to them when their oil revenues were high.

10. Energy developments that made sense with oil at $25 per barrel, suddenly made no sense at all with oil at around $10-$15 per barrel. New ventures in renewables, conservation and energy services have been halted or lost altogether. Massive investments in the search for new oil, and in the development of all the renewable energy sources that will be needed through the transition, have been shelved or placed in jeopardy.

11. As the Commission completed its Report in December 1986, world oil prices stood at around $10-12 per barrel (## to be updated at publication ##); many think that cheap energy has come to stay.

12. Looking to the next decade and beyond, it seems clear that, in the face of increasing economic activity and of constantly rising demand, the level of success by producers in controlling first, their market shares and then, the supply availability of oil will emerge as the decisive factor in determining prices. It is imperative, therefore, that a period of cheap hydrocarbon energy should not be taken as a permanent phenomenon. It may

temporarily set back, but ultimately, can in no way alter the fundamental character of the transition to a broader mix of energy sources, with a steadily increasing proportion of renewables.

13. How far will the very imperfect oil market and other institutional structures currently available to us worldwide, help us to avoid a future re-run of the very bumpy economic ride experienced globally during the last 13 years? The world can stumble through the coming transition, from oil shock to oil shock, at a great cost to sustainable development, and the environment. Or it can make an effort to manage the transition, by encouraging more sustainable mixes of energy supply and patterns of energy consumption and pricing. This, however, would require a vigorous transformation in our energy policies and institutions.

14. An effective arrangement to damp down the recent wild fluctuations in the world oil price, to reasonable levels would however be central to this transformation. This requires policies of institutional co-operation rather than market laissez faire.

15. An opportunity now exists to start building such an arrangement. The economic, social and environmental costs of losing this opportunity are much clearer today than they were in 1979. In the western industrialized countries the griplock between energy and development was finally broken during the past decade. The ratio of energy to economic growth fell in many countries, in some from 1.2 to 0.5 units (Figure 2), resulting in substantial gains in overall economic efficiency and competitiveness and substantial reductions in the costs

of environmental damage. The momentum that produced energy efficiency gains of up to 2 per cent a year is now threatened by low oil prices in transportation, industry, agriculture and other sectors and could quickly be lost.

16. Effective attempts to create more orderly oil pricing will take many years to negotiate. In the meantime, nations may choose to allow consumer prices to fall to levels dictated by the market or they may deploy various measures to sustain prices at higher levels. At the moment, it is the former course that is generally being pursued. In the longer term, with unrestricted demand gradually overtaking supply, the stage may well be set for yet another energy shock, and a repeat of the economic, social and environmental experiences of the 1970s.

17. On the other hand, consumer nations and especially the major industrialized countries could take steps to sustain prices at somewhat higher levels and wherever possible, capture in their budgets a major proportion of the gap created by the sudden collapse of world oil prices.

18. For many countries this would be extremely difficult because of domestic political and international economic constraints. Perhaps the only genuine solution lies in the steadily growing realization that oil is such a crucial raw material in future strategies for environment and development that it is too important to be treated as just another commodity and left to the vagaries of a volatile and very imperfect world market. Instead, both producers and consumers should co-operate to develop policies to reduce the wild fluctuations in prices that have been so disruptive globally during the last 13 years and aim for the more orderly production and marketing of oil. If this cannot be achieved, this

Commission greatly fears that it will extremely difficult to carry through any coherent energy and development strategies for the future in the face of wildly fluctuating oil prices.

(Rec 6.1)

Governments should whenever feasible

* keep prices of oil and oil products at a level adequate to maintain the steady gains in energy efficiency being achieved prior to 1985 and thus avoid losing momentum in the transition: to a lower energy future; to increased utilization of renewable energy sources; and to improved economic and environmental performance.

(Rec 6.2)

Nations should make every effort to co-operate on measures to

* steady the world market in oil;

* reduce the extreme fluctuations in oil prices and

* ensure that in the future the world energy system will be more stable and predictable than the disruptive disorder that has prevailed since 1973.

(Rec 6.3)

A pair of "northern" and a pair of "southern" producer/consumer nations (e.g. Norway/Sweden and Kuwait/Jordan) should convene a small Technical Group of economists, political scientists, energy- and policy-analysts to:

* develop a common information base related to problems of trade in oil;

* examine the economic, institutional and other mechanisms and arrangements available or needed to negotiate and oversee a reduction in price fluctuations;

* report to ECOSOC with recommendations on the data base, process and substance of the further steps to be taken.

III. A HIGH OR LOW ENERGY PATH

19. How far can these unsustainable energy trends be reduced or avoided in future? The major strategic choice before governments and the world community is illustrated in Figure 3, which reflects some of the better known projections of energy use through to the middle of the next century, arrived at as a result of a number of very careful analytical studies.[6/] In examining Figure 3, it is essential to understand that these energy use projections are not in any sense predictions of the future. They are projections of current states, logically extrapolated into future trends that might occur under different, pre-set assumptions about the ways that energy could be managed by societies globally. Thus, whilst they are not forecasts, they are helpful in clarifying the logical consequences of bringing in a given set of energy policies. They can also be used to indicate the economic and environmental implications of higher or lower energy futures.

20. It will be seen that by the year 2000, global energy consumption could in theory vary by a factor of five between the lowest and the highest projections, and by the year 2020, the difference between the projections is too large to portray on this Figure.

21. Two of these projections have been selected to represent respectively a credible "upper bound" and a credible "lower bound".[6/] The purpose in selecting these "extreme" projections, is to show how two radically

different energy futures are possible, reflecting completely different policies and institutional arrangements. The projections also provide boundary limits within which to discuss the consequences of two broad directions for development and its sustainable environmental basis.

22. The "high" scenario is indicative of the direction in which energy consumption and supply patterns are heading if existing policies and institutions remain essentially unchanged. It is a normative trend scenario. It is included in a carefully validated study published in 1981 by the International Institute for Applied Systems Analysis[2/]. It projects a tripling of global energy consumption over 1980 levels by 2020. This would necessitate an enormous increase in supply levels which the study demonstrates to be at least technically feasible. Additionally, there would be a consequent tripling of potential environmental impacts. Although this scenario is highly instructive, most energy observers nowadays consider that it is unlikely to be realized in future. Nevertheless, the study is probably a good representation of a possible "upper bound" for how the energy future might unfold in the next forty years.

23. The most recent examination of the technical feasibility of reaching a "low" energy future is that contained in a 1985 study by an international group of energy analysts.[14/] It demonstrates what could be achieved if all future development incorporated the most energy-efficient technologies and processes now available and in use in the domestic, industrial, transportation and other sectors. Assuming this were possible, the study allows for a 50 per cent per capita drop in primary energy consumption in industrialized countries and a corresponding 30 per cent increase in developing countries by the year 2020.

24. These and other assumptions produce a mere 10 per cent increase in primary energy consumption globally by 2020. This striking figure is of great interest when it is remembered that this scenario permits economic growth rates similar to those associated with the "high" scenario.

25. The "low" scenario assumptions imply that average annual gains in energy efficiency of 3.3 per cent and 2.7 per cent can be reached and sustained in industrialized and developing countries respectively. Additionally, the study indicates that the extra foreign exchange needed to buy energy efficient end-use equipment is more than offset by the cost savings made by reducing the amount of new supply installation needed. For instance, in Brazil, the fully discounted costs of all the investment needed to replace normal incandescent light bulbs with compact fluorescent types over a 50 year life cycle, is three times less than what would be needed to instal new supply facilities equal to the amount of electricity saved. While this approach may be technically and economically feasible, it presumes huge structural changes, needed to satisfy the very high rates of penetration of energy efficient technologies and processes. This presumption is probably not fully realizable, bearing in mind previous experience and the well known economic, social, institutional and political inertial constraints to change. Nevertheless, the study is a most valuable and salutory representation of a technically, if not at present societally, feasible "lower bound" of how the energy future might unfold in the next forty years.

26. The energy supply implications of a "high" energy future are alarming. By the year 2020, oil and natural gas would have to be produced at x1.5 and x2.9 the 1980 rates respectively, while coal production would need to increase by a factor of x4.0. With all the attendant

increases in resource exploitation, cleaning and transport, these tasks are regarded by most as well beyond present-day logistical capacity. This increase in fossil fuel use implies a capacity equivalent to bringing a new Alaska Pipeline (2 million barrels of oil equivalent -mboe-day) into production every two to three years even if existing oil production is maintained. (It should be noted that the 1980 level of oil consumption carried through to 2020 would exhaust existing reserves, and would require the discovery of 20 per cent more proven reserves than existed in 1985.[12/]) More than 6 Terawatts (TW -is a thousand million kilowatts: 1 TW of energy emitted continuously for a year is approximately equivalent to the quantity of energy liberated by burning 1000 million tonnes of coal) of nuclear capacity would also have to be installed by the year 2020, an increase of 3,000 per cent over 1983 levels!. This is equivalent to installing one new 1-GW(e) nuclear power electricity generator every 2-3 days.

27. In the case of the "low" energy future, the implications for energy supply are still very considerable, but perhaps more manageable. Oil and coal would be used at rates approximately 20 per cent less than in 1980, and only nuclear, hydro and natural gas would increase from 1980 levels by factors of 3.4, 2.4 and 1.9 respectively. Since new additions to the supply of a particular energy source are proportionately much more expensive than existing sources, the potential gain by not having to open up new supplies could be very large indeed. The main problems of a low energy future, however, are on energy demand management, particularly by the deployment of end-use efficient hardware upon which immense pressure would be placed.

1. Consequences for the Global Economy and Environment

28. The economic implications of a high energy future are also substantial; investment requirements are enormous. According to World Bank estimates, US$130 billion would have to be invested every year in energy projects in order to raise per capita levels of commercial energy consumption in developing countries from 0.54 to 0.78 KW between 1980-1995 (which is necessary to reach the high projection by 2020). Moreover, half of this, that is US$65 billion a year (compared with the US$3.5 billion a year currently being loaned in the energy sector) would be in foreign exchange, equivalent to about 4 per cent of aggregate GNP of these countries.[6/] This level of investment, involving such a huge charge on foreign exchange earnings would push most energy importing developing countries further into the already serious debt crisis (Table 3).

29. The economic implications of a low energy future, on the other hand, could be beneficial. While achieving more or less the same level of economic growth as the high scenario, it does so with a much lower level of energy consumption. Not only are investment requirements and corresponding debt burdens lower, but also a slightly greater reliance on renewable forms of energy would have a higher employment impact, especially in rural areas. Lower levels of conventional energy production would also reduce the required investment to prevent or control environmental damage. In fact, greater reliance on energy efficiency and renewables, if properly managed, could lead to significant opportunities for environmental regeneration, providing an economic base for reforestation, wasteland reclamation and other measures.

30. Although it is not possible to quote a figure for the overall investment requirements of a low energy future, it can be shown that under a wide range of circumstances, the extra capital requirements for improved end-use technologies will be more than offset by capital savings made because of lowered energy supply needs.[14/] Although many of the pay-back times will be as long as 10-15 years, they will be worthwhile in the long run. In the case of Brazil, for example, it has been shown that for a discounted, total investment of $4 billion in more efficient end-use technologies (e.g., more efficient refrigerators, street-lighting, motors, etc..) it would be feasible to defer construction of 21 gigawatts of new electrical supply capacity, corresponding to a discounted capital savings for new supplies of $19 billion in the period 1986 to 2000.[16/]

31. A high energy future with its heavy reliance on fossil fuels and its huge requirements for investment in other conventional sources of energy, carries equally serious environmental implications.

32. In terms of fossil fuel use, for example, it would result in substantial increases in the consumption of coal, oil and natural gas. It is the increase in coal, which requires most attention, since the environmental and health impacts of coal are greater than those of oil or gas. Overall, there would be more than a doubling of the production of carbon dioxide, which would bring the world much closer to possible major climatic changes. Increased fossil fuel combustion in power stations as well as in automobiles would also aggravate the problem of cleaning up the emitted oxides of sulphur and nitrogen.

33. In developing countries, the indirect environmental impacts of such a high energy future could be very serious. Local energy supplies would have to be greatly increased. Carelessly installed energy development projects, such as the construction of large hydro-electricity dams, have already contributed unacceptably to land degradation and other environmental damage. Sweeping improvements in energy installation methods would be essential therefore, to limit further widespread harm to the environment.

34. Added to this, the very large energy costs implied by such a high-energy future will require energy importing developing countries to step up commodity production for export (as opposed to production for local consumption) to be able to pay for the higher external debts incurred. More good, rain-fed or irrigable land would have to be devoted to non-food, export oriented agricultural production, which means either the opening up of more forests (i.e., deforestation) and/or the marginalization of even more subsistence farmers onto fragile soils and other lower quality lands. In both cases, subsistence food production and the environment suffers in the process. Deforested land in the tropics loses its fertility rapidly, and results in eroded topsoils. Marginalized farmers are obliged to overuse the low quality soils, and the results are again the same: soil degradation and erosion, silting up of reservoirs downstream, and eventually flooding. In all cases, the impacts have tremendous developmental costs, which society as a whole has to pay for.

35. In the case of a low energy future, there will remain a large number of environmental impacts to be avoided or abated. There will, however, be virtually no increases above the 1980 levels. In fact, although fossil fuel use remains essentially constant, there may

be a small drop in the rate of carbon dioxide production due to changes in the fossil fuel mix (i.e., more natural gas and less coal and oil). This would slow down the rate of climatic change, giving more time for the world community to deal with the problem.

2. Priorities for Survival and Development

36. Given the interrelated economic, environment and development implications of the high and low energy scenarios, there seems little doubt that the nations of the world should aim for the absolutely lowest possible energy future achievable under their economic and social priorities and constraints.

37. If the low energy scenario could actually be fully achieved, it would be sufficient to target future policies on decreasing the energy content of development and controlling the emission of pollutants. But if, as seems likely, for various institutional and investment reasons,substantial increases in energy consumption will take place unavoidably, then all nations, and particularly developing countries will have to explore urgently all avenues for increasing the supply of energy in environmentally benign ways, particularly from renewable sources. In any event energy efficiency is the crucial goal and every effort must be made to achieve it worldwide.

(Rec 6.4)

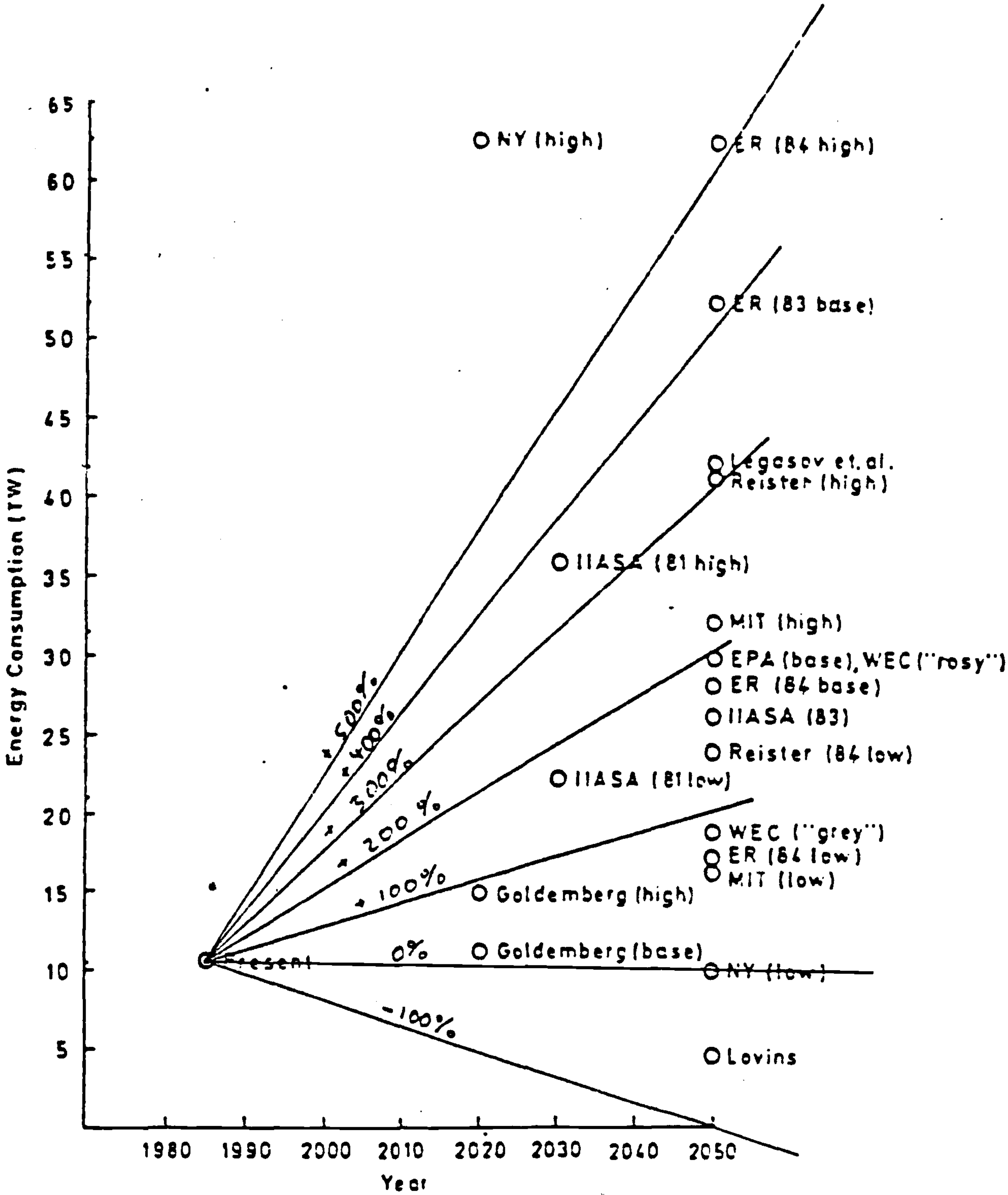
Governments should

* place energy efficiency at the top of their national energy agendas and

* develop policies designed to achieve the lowest possible energy consumption future, compatible with economic, social and environmental opportunities and constraints.

FIGURE 6-3

Projections of Primary Energy Consumption in the Future



Note: The circles represent actual projections, while the lines show percentage variation from the 1985 (actual) level, in units of 100 per cent.

Source: After Keepin et al - 1985[6]

IV. ENERGY EFFICIENCY: MAINTAINING THE MOMENTUM

38. From the preceding discussion it is obvious that energy efficiency should be the cutting edge of national energy policies for sustainable development. Measures to achieve it deserve the highest priority on national agendas. Although impressive gains in energy efficiency have been made since the first oil-price shock thirteen years ago, the recent plunging oil market has stalled or even reversed this progress in several countries.

39. The cost effectiveness of efficiency as the most environmentally benign "source" of energy is well established. There are so many cases where the energy consumption per unit of output from "best practice" technologies is one third to less than half of typically available equipment. This is true of appliances for lighting, refrigeration and space cooling, needs which are growing rapidly in most developing countries and putting severe pressures on the available electricity supply systems. It is true of cooking fires and cooking equipment, with all their impacts on the sustainability of tree cover, the recycling of crop and animal residues now burnt for fuel, as well as on soil degradation and erosion. It is also true of agricultural cultivation and irrigation systems, of the automobile, and of many industrial processes and equipment.

40. The cement factory, automobile or idling irrigation pump in a poor country is no different from its equivalent in the rich world. In both cases there is roughly the same scope for reducing the energy consumption (or peak power demand) of these devices without any loss of output or welfare. But in a poor

country the benefits thus gained will mean much more. The woman who cooks in an earthen pot over an open fire uses perhaps eight times more fuel than her affluent neighbour with a gas stove and aluminium pans. The poor who light their homes with a wick dipped in a jar of kerosene get one hundredth of the illumination of a 100-watt electric bulb and use just as much energy to do so. These examples illustrate the tragic paradox of poverty. It is not shortage of energy, but rather shortage of money which is the limiting factor for the poor. They are forced to live on a meagre "current account", and thus use "free-good" fuels and inefficient equipment, because they do not have the cash or savings to purchase energy efficient fuels and end-use devices. Consequently they finish up paying many times over for a unit of delivered services.

41. While there are countless examples of successful energy efficiency programmes in industrialized countries, these programmes still face a large number of barriers in developing countries. In all countries, ignorance tends to be the most important constraint. Many consumers, including large industries, do not really know exactly how they use energy, what it costs them, how costs can be reduced, or how to set about reducing them. Information campaigns in the media, technical press, schools, etc..; demonstrations of successful practices and technologies; free energy audits; energy "labelling" of appliances; training in energy-saving techniques; and many other methods have been used successfully to increase awareness and they urgently need to be extended widely.

42. Ignorance breeds indifference, tendencies which are reinforced by energy pricing policies that may include subsidies and seldom reflect the real costs of producing or importing the energy, let alone the external damage costs to health, property and the environment. Countries

should evaluate the overall costs to government and society of the different energy options, both renewable and non-renewable, with all hidden and overt subsidies included to see how far the real energy costs can be passed on to the consumer. The true economic pricing of energy - with safeguards for the very poor - needs to be extended in all countries.

43. There are more subtle but no less important price and cost distortions. Energy efficiency measures which reduce peak electricity demand and thus postpone the need for investment in additional capacity are a case in point. Frequently, the ratio of the cost of avoided supply to the cost of the efficiency measure is two or three to one. In these and similar cases, there are strong arguments for systems to enable those who invest in energy efficiency measures to capture more of the financial rewards. Remodelling consumer pricing structures so that sharp tariff increases are made to users consuming electricity beyond a certain base-level which is costed at lower than normal rates has this effect. This two tier tariff system commonly used in California and elsewhere is also fairer to the utility needing to install additional supply.

44. Many energy efficiency measures cost nothing to implement. But where investments are needed, they are frequently the main barrier to successful implementation, even when pay-back times are short. These barriers are often absolute for the poor consumer or for small informal sector entrepreneurs. In these latter cases, special small loan- or hire purchase-arrangements will be necessary. Where investment costs are not insurmountable, there are many mechanisms for reducing or spreading the initial investment hurdle which can be adopted, ranging from tax credits and loans with favourable repayment terms where appropriate to

"invisible" measures such as loans repaid by topping up the new, reduced energy bills to the pre-conservation levels, or value added tax relief on the sale of energy efficient end-use devices, or similar types of subsidy measures.

45. Developing countries face particular constraints in this area. They frequently have foreign exchange difficulties which make it hard to purchase efficient, but costly energy conversion and end-use devices. Additionally, many effective measures for energy savings often turn out to be the "fine tuning" of already functioning systems. These do not always appear as attractive for funding to aid-agencies or local government officials as do new, large-scale energy supply hardware and other installations which are often perceived as more tangible and concrete symbols of progress.

46. The manufacture, import or sale of equipment conforming to mandatory minimal energy consumption or efficiency standards is one of the most powerful and effective tools in promoting energy efficiency and producing predictable savings. Where the equipment concerned is traded internationally, these may require international co-operation. Countries, and where appropriate, regional organizations, should introduce and/ or extend increasingly strict efficiency standards for equipment and mandatory labelling of appliances.

1. Transport

47. Transport has a particularly important place in national energy and development planning. It is a major consumer of oil, accounting for 50 - 60 per cent of total petroleum use in the majority of developed and developing countries. It is frequently a major source of local air pollution and regional acidification of the environment.

48. Looking to the year 2000 and beyond, vehicle markets will grow much more rapidly in developing countries, adding greatly to potential air pollution in cities where international norms are already being exceeded. Indeed, unless strong action is taken, air pollution could become a major factor limiting industrial development in many Third World cities. In this context, fuel economy emerges as the most cost-effective means both to prevent further growth in air pollution from vehicle transport and to preserve a region's capacity for sustainable development.

49. With higher prices, fuel economy becomes a high-visibility issue for consumers as well as governments. It can continue to be a driving force behind technical innovations directed at dealing with a changing operating environment and gaining competitive advantage in the market place. In the absence of higher prices, mandatory standards providing for a steady increase in fuel economy may be necessary. Either way, the potential for substantial future gains in fuel economy is enormous; improved body design, material substitutions, and engines and power trains are some of the technical paths now being pursued. If the momentum can be maintained, the current average fuel consumption of approximately 10 litres per 100 kilometres in the fleet of vehicles in use in developed countries could be cut in half by the turn of the century.[5/]

50. A key issue is how developing countries can secure similar improvements in the fuel economy of their vehicle fleets especially when their average fleet life is often double that of an industrialized country, leading to halved rates of renewal and improvement. Those countries that import their fleets, could lay down improved standards for new vehicles. However, in those countries where vehicles are assembled under licence with

industrialized country manufacturers, the situation is different. The designs are frequently older and predate energy efficiency improvements. These countries should give priority to the reforms of licensing and import agreements under which they will have access to the best available fuel efficient designs and production processes.

51. If the rate of fuel saving fails badly to keep pace with the fuel increases required by the rising demand for more transport, oil importing developing countries should explore the potential in non-oil based transport fuels. Some actually have. The obvious candidate is ethanol and the experiences of Brazil, Kenya and Zimbabwe are very informative here.

2. Industry

52. Industry is also a major source of energy demand accounting for 40 - 60 per cent of all energy consumed in industrialized countries and 10 - 40 per cent in developing countries. Like transport, it is one of the main causes of pollution, especially in those countries that have not implemented strong environmental programmes over the past two decades.

53. Most trends point to a very rapid growth of industry around the turn of the century, but the form and pattern could be markedly different between industrialized and developing countries. Industry in the former has been evolving fairly rapidly, undergoing a massive restructuring marked by a shift away from heavy industry towards higher technologies, the substitution of synthetics for natural inputs, and a growing de-commoditization of production in favour of "hi-tech" and service-industries. At the same time, there has been significant improvement in the energy efficiency of production equipment, processes and products. The

innovation behind these improvements has been driven by the availability of a skilled workforce, but also largely by higher energy prices. Nowadays, plants that are comparatively energy efficient and hence more environmentally benign and economically competitive are common in every industrial sector.

54. During this period, the more energy intensive and polluting industrial processes have tended to accumulate in developing countries. Multinational corporations have often been criticized for installing older or less clean technologies in developing countries, although it is usual for industrialization to start-up with the heavy industries such as metal smelting, which require a less skilled labour force but tend to be intrinsically more polluting. The key issue, again, is how can developing countries ensure that future industrialization reflects the most advanced and resource efficient technologies available in each of the sectors concerned. Several measures seem within reach. Those countries that permit industrial concerns to import plants on a turn-key or similar basis, should ensure that all licences provide for the best available energy- and environmentally-efficient technologies and processes. Moreover, such arrangements should require approval of plans for the safe management of all waste products. Development assistance, export credit and other international financing agencies involved should ensure that all these features are included in the financial plans of the industry.

55. Developing countries often need to decide on the comparative advantage of the home production of industrial components. In suitable cases, the most energy intensive and polluting components might be imported, leaving the others to be made locally, thus achieving a far lower overall energy intensity and

environmental penalty for the final product. Energy savings of as much as 20 - 30 per cent could be achieved by such skillful manipulation of industrial development.

56. The proper maintenance of industrial plant, especially older equipment, can also save much "down-time" and can pay real dividends in terms of energy saving. Industry-oriented energy conservation programmes, managed perhaps by an "energy services utility" with incentives to help existing industries to identify cost-effective opportunities for saving energy, could reduce energy demands by a further one third. Savings of this order will not only improve the competitiveness of a nation's industrial sector but also its balance of payments, reduce its debt requirements and increase the capacity of the environment in the cities of developing countries to accept more development.

3. Agriculture

57. Globally, agriculture is only a modest energy consumer, accounting for about 3.5 per cent of commercial energy use in the industrialized countries and 4.5 per cent in developing countries as a whole. A strategy to double food production in the developing countries through widespread increases in fertilizers, irrigation and mechanization would add 140 million tons of oil equivalent to their agricultural energy use. This is only some 5 per cent of present world energy consumption and almost certainly a small part of the energy that could be saved in other energy sectors in the developing world through appropriate efficiency measures.

58. Agriculture is usually the least energy-intensive sector in national economies and the one with the highest economic and social return for each extra unit of energy input. The western industrialized countries have

established clearly that the "high food - high energy" linkage can be broken. While energy use has grown, energy efficiency has grown even faster permitting a significant rise in productivity.

59. Agriculture in developing countries, on the other hand, suffers from low or inadequate levels of energy use and productivity and the potential for increasing both is enormous. It is hard to find examples where increasing levels of energy use does not bring more than proportional increases in yield, income and profits.

60. Selective mechanization with small machines and improved use of animal draught power are also important energy interventions to break labour bottlenecks, significantly improving productivity and, in many cases, allowing double or even triple cropping. Access to more conventional sources of power would also pay high dividends in increased productivity. Farmers, for example, require energy to pump water for irrigation and other uses, or diesel for tractors, and they require it at precise times of the year. If they do not get it because of priorities elsewhere, yields suffer or crops may fail entirely.

61. The main constraints to increasing energy for agriculture in developing countries can be traced to unbalanced and inequitable development policies. Although there are vast differences in the political and economic power of rural societies to command energy resources, and genuine problems of resource distribution in rural areas, a balanced development strategy could achieve much in minimizing these problems.

4. Buildings

62. Although there is still enormous scope for improvement, perhaps the most widely understood ways of increasing the efficiency of energy consumption are in the home and workplace. Buildings in the tropics are now commonly designed to intercept the minimal amount of direct heating from sunlight by having very narrow east and west facing walls, but with long sides facing north and south and shaded from the angle of the overhead sun by recessed windows or wide sills. Such passive design maximizes shade and reduces air-conditioning costs drastically. Conversely, in cold climates, long, south-facing walls are designed to trap the warmth of the low sun. Plastic foam or other forms of cavity-wall and roof insulation together with double or triple glazing are commonly standard features of the carefully draught proofed buildings of many colder countries, where space heating is achieved by time-switched, thermostatically controlled warmth from electricity or fossil-fuels. An important environmental problem in such "airtight" house is the build-up of radiation from the radioactive gas radon, generated from the decay of radium occurring naturally in the building materials derived from some granitic rocks in parts of certain countries, especially Scandinavia and North America. When it is present, it may confer on average, 50 - 60 per cent of the total annual radiation does received by the human body from all sources. In Sweden, various percentages (up to circa. 10) of the total human lung cancer burden have been ascribed to it and under these conditions, a certain level of ventilation is desirable to prevent radon accumulation and avoid the problem altogether.[17/]

63. Another very important method of heating buildings is by hot water, co-generated during electricity production and piped around whole districts to provide warmth and hot water. This extremely efficient use of fossil fuels demands the co-ordination of energy supply with local physical planning which few countries at present are institutionally equipped to handle. Where it has been highly successful, there has usually been local authority involvement in or control of regional energy-services boards, e.g. in Scandinavia and U.S.S.R. Given the development of these or similar institutional arrangements, co-generation could revolutionize energy efficiency in the heating and hot-water provision of buildings worldwide.

5. Conclusions

64. From the foregoing discussion it is obvious that energy savings, through the efficient use of fuels and power, should be top priority in any national energy policy. The whole battery of measures required to achieve this are already well known and many are referred to in the preceding text; they should be at the head of every national energy agenda. It is technically feasible to save at least one third and commonly a half of the energy currently being used in nearly all sectors of the economy. Not only does it make good sense economically particularly when foreign exchange is involved, it is also the most environmentally benign method of energy management.

(Rec 6.5)

Governments, through ECOSOC, should request the North-South Energy Round Table to

* convene a Technical Working Group to draft a "World Strategy for Energy Productivity" detailing the specific actions needed to pursue energy efficiency in all sectors of a national economy in order to

  ** achieve and maintain annual reductions in energy requirements per unit of output, and thus

  ** improve both economic and environmental performance; and

  ** report back to ECOSOC with recommendations for further action.

(Rec 6.6)

Governments should

* adapt the "World Strategy for Energy Productivity" and reflect it in

  ** a similar "National Strategy" which recognizes the specific, socio-political, economic and environmental opportunities and constraints before it; and in

  ** guidelines for government agencies, parastatals, the private sector, consultants and other bodies that influence energy policy, supply and consumption.

(Rec. 6.7)

Governments should

* develop comprehensive comparisons of the benefits and costs of increasing energy supply from various energy sources available to a nation versus reductions in demand through appropriate energy efficiency measures;

* in these comparisons, take into account health, environment, occupational safety, employment, foreign exchange, and other costs of obtaining, transporting, utilizing energy, including waste-disposal costs.

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65. Energy efficient end-use appliances are not necessarily less environmentally polluting in themselves. But the reduction in health and environment impacts from the fuels saved, and from the new power supply installations which do not need to be built as a result of a conservation strategy, are very large. A vigorous drive towards energy efficiency puts pressure on a whole range of investment programmes both large and small in all sectors of the energy economy to replace old, inefficient end-use appliances. This requires a fundamental change in the institutional arrangements for energy. Major investment in more energy supply by utilities has to be phased out and replaced by major investments in energy efficient hardware provision and in energy accounting and energy-services expertise.

66. At present, energy industries providing electricity, oil and gas are very strongly integrated around the complete control of production of the particular energy source and its distribution. Attempts are naturally made to reach back upstream to the primary energy source and convert it. Thus, electrical utilities strive to control hydropower and nuclear energy, gas utilities are interested in coal gasification, whilst oil concerns have considered its liquefaction. By contrast, their downstream management of energy end-use is weak and insensitive, because it is usually perceived merely as a product-marketing exercise where the aim is to persuade customers to find more and more uses for a saleable product. The idea that it would be highly profitable to embark on the production, sale or financing of energy-efficient end-use equipment tends to be seen by most utilities as being at odds with the whole thrust of their supply philosophy.

67. In practice then, this means a fundamental intellectual jump for utilities if they are to provide such services. Such an institutional change requires enthusiastic participation and even organized pressure on utilities by consumers in all the energy sectors in order to keep up the momentum of change. Ideally of course, it would be far more efficient both in energy and institutional terms to develop agencies responsible for the local distribution and marketing of end-use appliances and also for all forms of energy bought wholesale from the large utilities and retailed to the consumer in the form of complete and efficiently integrated energy services. This could be achieved by private companies, local-authority linked energy boards, co-operatives or any other form of local institution appropriate to the political economy of the country concerned. Such a development is unlikely to occur without determined consumer pressure because of the monopolistic nature of many utilities.

(Rec 6.8)

Governments should encourage the private sector, local authorities, co-operatives or public utilities to

* invest in selling energy services (energy efficiency advice; audit expertise; energy intensity analyses; approved energy efficient hardware; installation and maintenance services; financial support packages).

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68. The key to this consumer catalysis is a national information campaign to heighten awareness of the economic and environmental benefits of energy conservation. Governments can set up a series of district energy efficiency centres to demonstrate the benefits of efficient building insulation and end-use equipment. Such centres should demonstrate the whole

TABLE 6-3

Energy Imports as a Percentage of Merchandise Exports in Developing Countries

Country	1983	Country	1983
Central & South America		**Africa**	
Argentina	9 %	Algeria	2 %
Brazil	56	Burkina Faso	50
Chile	24	Cameroon	4
Colombia	21	Egypt	12
Costa Rica	22	Ivory Coast	16
Dominican Rep	71	Madagascar	32
El Salvador	57	Morocco	57
Guatemala	68	Niger	17
Honduras	28	Senegal	58
Nicaragua	46	Sudan	57
Panama	82	Togo	18
Paraguay	1		
Peru	2	**Asia**	
Trinidad& Tobago	4	Bangladesh	20
Uruguay	28	Hong Kong	7
Venezuela	1	Indonesia	20
		Korea, Rep of	28
Europe		Malaysia	16
Greece	59	Pakistan	49
Portugal	48	Philippines	44
Turkey	66	Singapore	40
Yugoslavia	33	Sri Lanka	40
		Thailand	39
		Middle East	
		Jordan	101

Source: World Bank 1986 "World Development Report 1985"[15/]

range of energy efficient equipment with all pay-back times and installations services fully detailed. Such centres when set up, have been extremely successful in educating and generating public action in all energy sectors.

(Rec. 6.9)

Governments should

* set up "energy centres" at appropriate locations to offer advice and give demonstrations about specific measures to achieve greater energy efficiency in industry, transport, agriculture and household. These should provide information on:

  ** energy audits;

  ** criteria and standards for the importation, production, and labelling of buildings, vehicles, end-use appliances and other energy equipment;

  ** costs, estimated pay-back times on outlays, from the energy saved;

  ** tax, energy-tariff credits and other forms of financial incentives and support available on approved energy related materials or hardware.

  ** energy services facilities available to customers.

(Rec 6.10)

Governments should

* mount public information campaigns with full media coverage, explanatory booklets and travelling exhibitions based on the work of the "energy centres";

* make energy productivity information available to architects, engineers, mechanics, farmers, commercial offices, hospitals, schools, and similar institutions.

(Rec. 6.11)

NGOs should

* support the "energy centres" (Rec 6.9) and energy services initiatives (Rec 6.8) by promoting grassroots energy savings campaigns, employing the media, phone-ins, etc..

V. RENEWABLE ENERGY: UNTAPPED POTENTIAL

1. Improving Future Prospects

69. Renewable energy sources provide almost 22 per cent of the energy consumed worldwide, of which 15 per cent is biomass and 6 per cent hydropower. However, most of the biomass is in the form of fuelwood and agricultural and animal wastes used by about 70 per cent of the populations of developing countries. Table 1 shows the overall relationship of renewable to non-renewable sources; Table 4 provides a more detailed breakdown of the future prospects for renewable energy. In many cases fuelwood has already become a non-renewable resource because usage rates have overtaken sustainable yields. In this sense, although worldwide reliance on all these sources has been growing by more than 10 per cent a year since the late 1970s, the world is still far off the point when potentially renewable energy sources used in a truly renewable manner make up a substantial portion of the world's energy budget. Table 5 highlights the main environmental impacts of renewables and Table 6 proposes a tentative multiple ranking for the various categories of harm potential posed by renewables in comparison with non-renewable sources.

TABLE 6-4

World Use of Renewable Energy, 1980, 2000 and Potential[18/]

Source	1980	2000	Long-term Potential
		(exajoules)	
Solar energy: passive design	0.1	3.5-7	20-30
Solar energy: residential collectors	0.1	1.7	5-8
Solar energy: industrial collectors	0.1	2.9	10-20
Solar energy: solar ponds	0.1	2-4	10-30+
Wood	35	48	100+
Crop residues	6.5	7	-
Animal dung	2	2	-
Biogass: small digesters	0.1	2-3	4-8
Biogas: feedlots	0.1	0.2	5+
Urban sewage and solid waste	0.3	1.5	15+
Methanol from wood	0.1	1.5-3.0	20-30+
Energy crops	0.1	0.6-1.5	15-20+
Hydropower	19.2	38-48	90+
Wind power	0.1	1-2	10+
Solar photovoltaics	0.1	0.1-0.4	20+
Geothermal energy	0.3	1-3	10-20+
Total	64.3	113-135	334-406+

Notes: + indicated that technical advances could allow the long-term potential to be much higher; similarly, a range is given where technical uncertainties make a single estimate impossible.
means less than.

Source: Worldwatch Institute. Deudney & Flavin - 1983.[18/]

TABLE 6-5

Potential Environmental Effects
of Renewable Energy Sources

Direct Solar Heating and Cooling

- Injuries in rooftop collector maintenance.
- Property or ecosystem damage from leaks of working fluid or storage medium.
- Fire caused by collector overheating.
- Release of toxic substance in fires of any origin.
- Penetration of toxics in working fluid from heat exchanger into drinking water.
- Pollution from degradation of selective collector coatings.
- Hazard from falling collector glass in earthquake, fire, etc.
- Water use and emissions by wet cooling towers for commercial air conditioning.
- Transport of allergenic moulds and fungi from storage system to room interiors.
- Removal of shade trees.
- Nuisance caused by collector glare.
- Roof leaks from improper collector installation.

Solar Thermal Electricity Generation

- Effects of induced population increase in fragile desert regions.
- Concentrated light beam as burn or eye hazard to workers, birds, pilots, passers-by.
- Receiver tower as occupational and aircraft-navigation hazard.
- Pollution from leakage or disposal of working fluid or storage medium.
- Pollution from cleaning compounds for mirrors and/or collectors.
- Water use and emissions by wet cooling towers.
- Fires and associated release of toxic substances.

Terrestrial Photovoltaics

- Unusually toxic substances as manufacturing and fire hazards.
- Outgassing of PCBs from power conditioners.
- Effects of induced population increase in desert regions (in central-station mode).
- Burn and shock hazards from dispersed arrays.
- Chemical, electrical, and explosive hazards from storage batteries.
- Pollution from collector cleaning compounds.
- Pollution from disposal of degraded cells.
- Removal of shade trees (dispersed mode).

TABLE 6-5
- continued -

Wind Power

- Accident hazard from blade failures and toppling towers.
- Bird and insect kills.
- Fall hazard during maintenance.
- Interference with electromagnetic communications.
- Aircraft navigation hazard.
- Chemical, electrical and explosive hazards from storage batteries.
- Noise.

Hydropower

- Loss of scarce environmental resources: free.flowing rivers and fertile bottom land.
- Alteration of downstream river and estuary ecosystems.
- Water losses to infiltration and evaporation, the latter with microclimate impacts.
- Risks of catastrophic dam failure.
- Barrier to fish migration.

Ocean Thermal Energy Conversion

- Altered temperature, currents, and nutrient patterns, disrupting marine ecosystems.
- CO_2 release from saturated deep water, affecting climate.
- Pollution from leaks of working fluids and anti-biofouling chemicals.
- Entrainment of organisms.
- Ship collisions, with potential pollution from ship as well as power plant.

Biomass

- Dust emissions from agricultural and silvicultural activities.
- Water use where irrigation is required.
- Pollution from pesticides, herbicides, and fertilizer residues.
- Pollution by solid/sludge residuals from conversion processes.
- Ecosystem effects of monoculture.
- Soil depletion and impaired water-flow control due to removal of crop.harvesting and logging residues.
- Increased erosion.
- Air pollution from conversion and combustion (including indoor pollution from wood-burning stoves - severe in developing countries).
- Fire hazard from wood-burning stoves.
- Deforestation.
- Pathogens from municipal and animal wastes.
- Accidents in transport of collected residues.

TABLE 6.5
- continued -

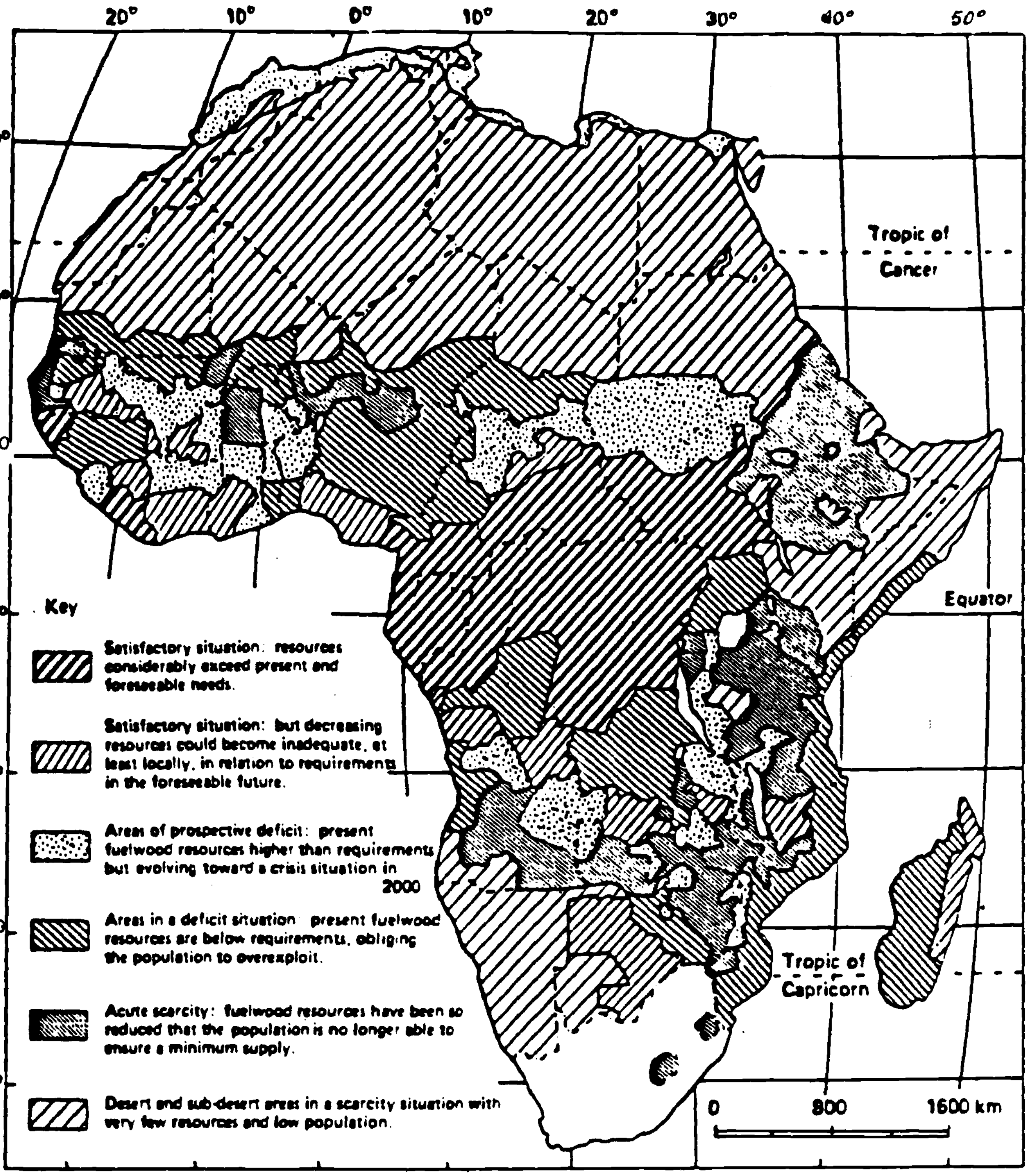
Biofuels (ethanol, methanol, and vegetable oils)

- Competition with food- or cash crops for agricultural land.
- Effluent wastes following processing have very high Biochemical Oxygen Demand and require costly effluent treatment plant before discharge to environment.
- Potentially toxic trace substances produced directly or by atmospheric chemical reactions following combustion (especially methanol).
- Additional engine corrosion problems (some vegetable oils only)

Source: All except Biofuels, selected from Holdren, 1982[19]

FIGURE 6- 7a

Firewood Availability in Africa, Present and Future



Source: Energy Policy, June 1986 22/

70. Wood as a renewable energy source is usually thought of in the context of the traditional domestic sector. However, wood is becoming an important feedstock for advanced energy conversion processes in both developing and in industrialized countries, including for the production of electricity and potentially for other fuels, such as combustible gases and liquids.

71. Hydropower, second to wood among the renewables, has been expanding at nearly 4 per cent annually. Although hundreds of thousands of megawatts of hydro power have been harnessed throughout the world, the remaining potential is huge, especially in the Third World.

72. Solar energy use is currently small globally, but it is beginning to assume an important place in the energy consumption patterns of some countries. In many parts of Australia, Greece and the Middle East for example, solar water and household heating is widespread. A number of East European and developing countries have active solar energy programmes and the United States and Japan support solar sales of several hundred million dollars a year. With constantly improving solar thermal and solar electric technologies, it is likely that their contribution will substantially increase. The cost of photovoltaic equipment has fallen from the original of circa. US$500 - 600 per peak watt to a current US$5. This optimistic evolution is approaching the US$1 - 2 where it can compete with normal electricity production. But even at US$5, it is still more cost effective than ranging power lines to remote places.

73. Wind power has been used for centuries - mainly for pumping water. Recently its use has been growing tremendously in some countries, such as off the California coastline and in Scandinavia. In these cases

the wind turbines are used to generate electricity, to be fed into the local electricity grid. Wind generated electricity costs have fallen dramatically in California in the last five years and will probably be the cheapest power generated there within a decade. Many countries have successful wind programmes, but the untapped potential is very high in all countries.

74. The Brazilian alcohol programme in 1984 produced about 10 billion litres of ethanol from sugar cane and replaced about 60 per cent of the gasolene that would have been required in the absence of the programme.[14/,16/,20/] The cost has been estimated at US$ 50-60 per barrel of gasolene replaced. When subsidies are removed, and a true exchange rate is used, this is competitive at 1981 oil prices. Although with the present oil glut the programme has become temporarily uneconomic, the programme saves the nation a great deal of hard currency, and provides additional benefits of rural development, employment generation, increased self-reliance, and reduced vulnerability to future crises in the world oil markets. It is particularly efficient at generating jobs - requiring an investment of $6,000 - $28,000 per job, which compares with an average of $42,000 for the Brazilian industry sector, and $200,000 for the oil-refining, petrochemical complex at Camarcari.[26/43/]

75. The use of geothermal energy has been increasing rapidly, more than 15 per cent per year, in both industrialized and developing countries. Exploration is expected to uncover a world geothermal capacity exceeding 10 gigawatts by 1990 and the engineering and other experience gained during the past decades could provide the basis for a major expansion in geothermal-rich countries.

76. Globally the potential for renewable energy sources is huge. Quantitative projections are difficult, both at the global or at regional or national levels. However, one estimate placed the long-term global potential at at least 10 TW years continuously (see Tables 1 and 4), a value equal to the 1980 level of energy consumption worldwide.[18/] This level could be substantially increased with new technologies. Whilst the rate at which renewables are developed will naturally depend on the widespread availability of suitable technology, it will depend overwhelmingly in the short run on policies that attack certain economic, environmental and institutional constraints to their use.

77. Most renewable energy systems operate best at small to medium scales, ideally suited for rural and suburban applications. They are also generally labour intensive, which should be an added benefit in situations of surplus labour. Additionally, they are less susceptible to wild price fluctuations and foreign exchange costs than fossil fuels. Finally, since most nations have some renewable resources, their use can help nations move toward the goal of self-reliance.

78. Yet, in spite of all these advantages, renewables are taking off very slowly, much slower than desirable. Now, given the low oil, and other energy prices, it is even less likely that renewables will increase faster than hitherto. Governments have not been considering these new energy sources sufficiently seriously in their plans. Renewables are still being measured with the same yardsticks as their non-renewable counterparts, which invariably means narrowly calculating the quantity of energy produced at a certain cost, and conveniently leaving out the environmental and social externalities.

79. This does not mean that renewable energy production need not make economic sense. It does mean, however, that the evaluation of all energy sources has to be much more conformably inter-comparable and comprehensive. The cost/benefit calculations must include all aspects, including avoided pollution costs, job creation, achievement of social goals, subsidies for non-renewable systems, etc..

2. Conclusions

80. The need for a steady transition to a broader and more sustainable mix of energy sources is beginning to become accepted. This favours the promotion of renewables. A low energy future, for example, would require decentralized energy systems, able to satisfy a wide range of end-uses, employing the most economically available sources. Very often, this will be various forms of energy saving measures. Or, it could be various forms of locally available renewables: active or passive solar; biomass; etc..

(Rec 6.12)

Except for naturally occurring biomass, which is at present dangerously overused in many regions worldwide, renewable energy sources are heavily under-utilized, and Governments should

* make special efforts to develop them, in particular solar, geothermal, wind and small hydro sources.

(Rec 6.13)

Governments, through ECOSOC, should convene a small Working Group to

* develop a "renewables assessment system" to provide

** a generic benchmark methodology flexible enough to be adapted for the specific purposes of national governments;

** a taxonomy and guidelines for the systematic assessment of the economic, social, health and environment costs and benefits of renewable sources against other energy sources, including conservation strategies (see Rec 6.7).

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81. Most renewables are characterized not only by decentralization, but also by diversity. Unlike non-renewables, this enables each country to tailor its energy economy to its indigenous resources. This reinforces self-reliance goals and reduces foreign exchange expenditure on imported fuel. Although every country possesses some sun, wind and biomass, some are better endowed with certain renewables than with others. Some may wish to rely on one locally abundant form of renewable energy; hydropower, for example. Others may be able to develop highly diversified renewable energy economies. Biomass gasifiers, biogas plants, small hydro installations, and most solar and wind systems work well on the small to medium scale and are often the best match for family and village or community use, especially in developing countries. Some large countries or regions, Brazil, India, North America, may wish to develop the entire range of renewable sources: from energy crops, including ethanol and wood fuel plantations through to wind, solar and photovoltaics. The outlays of foreign exchange are negligible with renewables, particularly if conversion hardware is locally manufactured. In addition, many renewable sources are virtually inflation-proof. Once the initial investment is made, the cost of running hydro and solar is tied to maintenance.

(Rec 6.14)

Governments should

* compile a national inventory of potential, sustainable supply and permissible end-use demand for renewable resources. (This should be done according to agreed conformable computerized energy data management formats).

* adapt and refine the "renewables assessment system" (see Rec 6.13) for national use in assessing available sources of renewable energy and encouraging their development through a "national renewable energy programme".

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82. The economic, social and environmental consequences of renewables require careful evaluation and comparison with non-renewables before deployment. Sustainability is the limiting factor with some renewables. Careless or excessive use may render them non-renewable, and consequently unsustainable. It is very important that these limits be continuously assessed and monitored in every country. Countries should undertake a full assessment of their potential for renewable energy, and the economic, social and environmental consequences of a steady shift to renewables.

(Rec 6.15)

Governments should

* require agencies exploiting renewable energy sources to take great care to minimize potentially adverse health, environment and developmental impacts (such as health risks from methanol fuels, erosion of catchments during hydro-dam installation, land degradation from unsustainable over-cutting of biomass.

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83. The fiscal and institutional barriers to renewables are formidable in many countries. The influence of temporarily low fossil fuel prices has already been noted. The high level of hidden subsidies for conventional fuels built into the legislation and energy programmes of most countries also distorts choices against renewables. These subsidies are legion, including not only in research and development, but also depletion allowances, tax write-offs and direct support of consumer prices. Countries should undertake a full examination of all subsidies and other forms of support to various sources of energy and publish the results. Additionally, electrical utilities often have a supply monopoly on generation which allows them to arrange pricing policies which discriminate against other (small) suppliers.

(Rec 6.16)

Governments should as far as possible

* remove present economic and institutional barriers to the development, sale and use of renewable energy sources;

Where the balance of costs and benefits for a renewable source is close to the result obtained from other energy forms, (Rec. 6.7 & 6.14), every effort should be made to

* discriminate in favour of the renewability option by allowing tax and energy-tariff rebates or other inducements to stimulate the deployment of renewables.

(Rec 6.17)

Governments should

* require electric utilities to purchase electricity generated from decentralized renewable sources at prices designed to stimulate their development.

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84. The costs of using renewables depend very much on their local availability compared with the usual commercial energy sources. A lot also depends on their "embedding" - the right societal infrastructure suitable to maintain them sustainably in the energy niche they are best able to fill. This means that the technology for exploiting renewables is generally speaking less of a problem than the fine tuning needed to fit them into a local energy demand pattern. This site and niche specificity is still poorly understood and will only emerge from a lot of working experience as well as a great deal more expenditure and effort on research, development and demonstration.

(Rec 6.18)

Development aid agencies should

* support governmental and multilateral efforts in research, development and demonstration in developing countries for renewable energy applications;
* give particular attention to the societal and energy "niches", renewables can occupy.

(Rec 6.19)

Governments should

* stimulate "energy centres" (Rec 6.9) and "energy services agencies" (Rec 6.8) to act as advisory and demonstration focal points for renewable sources, particularly for solar thermal (hot-water supply and the heating of building) and solar photovoltaic applications (such as electric fencing, lighting, telecommunications) including provision of data on pay-back times, and on financial and other inducements to encourage development, sale and utilization.

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85. The shift to a renewable energy economy in developing countries must include strategies for the stabilization and increase of sustainable wood production to satisfy growing demand, both in the traditional and in the modern sectors. This has to be carried out in environmentally favourable ways, which enhance and not reduce the countries' agricultural priorities.

86. Institutional barriers to renewables are formidable in many countries. Electrical utilities, for example, often have enjoyed a complete monopoly not only in power distribution (which is historically perhaps justifiable) but also in power generation. In some countries, a relaxation of this control, requiring utilities to accept power generated by industry, small systems and individuals, has created many opportunities for the development of renewables. Beyond that, requiring utilities to adopt an end-use approach in planning, financing, developing and marketing energy can open the door to a wide range of energy saving measures as well as renewables. All countries should consider this urgently and international development agencies should support it.

VI. WOOD FUELS: THE VANISHING RESOURCE

1. The Spreading Emergency

87. Although wood ranks only fourth in the world's energy budget after coal, oil and natural gas (see Table 1), almost half the world's population relies on it, mainly for cooking, and its use has been expanding at 2 per cent annually, i.e. parallel with population growth in developing countries. Wood fuels, such as fuelwood or charcoal are the most important energy source for over 2 billion people in developing countries, where 30 - 98 per

cent of all energy consumed comes from biomass. Recent studies and surveys seem to indicate, that on the average 70 per cent of the people in developing countries use wood and, depending on the availability, burn anywhere between an absolute minimum of circa. 350 kilogrammes, to a "luxury consumption" of circa 2900 kilogrammes of air-dried wood, with the average being around 700 kilogrammes per person per year.[21/]

88. Although wood fuels are in adequate supply in many countries, as indicated earlier (section II), it is being widely over-harvested and is therefore becoming effectively non-renewable, so that by the year 2000, unless counter measures are taken now, 3 billion people will suffer from a severe or absolute scarcity of wood fuel.[7/, 8/] Figure 6 shows the fuelwood situation in Africa. The "fuelwood crisis", as it is called is particularly hard-hitting for the vast number of poor, rural and urban households, whose survival depends on access to local supplies of traditional fuels like fuelwood, cow dung and crop residues. Given present trends, in the next few decades the fuelwood crisis will undoubtedly worsen and the theoretically renewable supply of trees will become increasingly non-renewable. Populations will grow substantially, and even if per capita consumption remains steady, total wood fuel demand will grow. It is estimated that the 1980 wood fuel demand potential of at least 2 billion cubic metres will grow to well over 3 billion cubic metres by the year 2000, and this at a time when, in many places, wood is already being harvested at levels higher than the sustainable yields.

89. At the same time unprecedented pressures are being placed on the same biomass base from the agricultural and urban-industrial sectors.[23/, 24/, 25/, 26/] Forests are being cleared at a rapid rate to open up new

agricultural land and much of this is induced by the need to produce more goods for export (tea, coffee, meat, etc..) to pay debts incurred to import oil or develop new sources of energy.

90. Some forest loss is inevitable, of course, to make way for human settlements, agriculture and industry. But deforestation causes soil degradation and erosion, siltation of reservoirs, reducing electricity production, flooding and loss in agricultural yields.[27] Thus, the continued rapid loss of forest cover will be environmentally, and hence economically, very serious for the regions concerned.

91. Yet, the fuelwood crisis and deforestation - although related - are not the same problems. On the one hand, wood fuels destined for the commercial markets for urban and industrial consumers tend to originate from forests. There are, therefore clear connections between urban-industrial wood fuel use and deforestation. On the other hand however, fuelwood used in the rural areas comes from a mixture of sources, such as from scattered trees around villages, along roadsides, and so on. In general only a small proportion comes from forests, and even in those cases not as a result of clear felling of whole trees, but rather from the collection of dead wood or cutting off of branches from trees.

92. When fuelwood is in short supply, people respond by economizing in consumption; and when it is no longer available, rural people are forced to burn biomass wastes, such as cow dung, rice husks, cotton stalks and weeds. In some cases these practices do no harm, since a true waste product is incinerated (e.g. cotton stalks). In other cases, however, much needed organic nutrients are diverted from the soil (e.g., animal manure, some biomass, etc..), and their diversion for

TABLE 6.6

Tentative Rankings of Environmental Impacts of Alternative Energy Technologies for Various Categories of Harm[1/]

	Public Safety	Public Health	Occupational Safety	Occupational Health	Climate Effects	Other Ecosystem Effects	Socio-Political Effects
HEAT AND FUEL							
passive solar heat	1	1	2	2	1	1	1
active solar heat	2	2	3	2	1	1	1
pond solar process heat	1	1	2	1	2	2	1
natural gas	3	3	2	1	4	3	1
imported oil	2	4	2	3	5	4	5
liquified coal	2	4	5	4	5	4	3
coal district heat	3	5	5	4	5	4	3
wood stoves	3	4	2	2	2	4	1
biofuels from wastes	3	3	3	3	2	3	1
biofuels plantations	2	3	3	3	3	5	2
ELECTRICITY							
imported oil-fired	2	4	3	3	5	4	5
coal-fired	3	4	5	4	5	5	3
nuclear (light water)	5	3	3	3	2	2	4
nuclear (breeder)	5	4	2	4	2	1	5
hydropower	5	1	2	2	3	5	3
wind	2	1	2	2	2	2	1
OTEC	1	1	3	2	4	4	2
pond solar electric	1	1	2	1	4	4	2
solar power tower	2	1	3	2	3	3	3
dispersed photovoltaic	3	2	3	4	2	1	2
orbiting photovoltaic	4	3	5	5	4	3	3
geothermal	1	2	3	3	3	3	1

Notes: 1/ For each category of harm, technologies are ranked relative to one another on a scale of 1 (best characteristics) to 5 (worst characteristics). Severity criteria are those described in Table 6-4, but rankings are necessarily both tentative and subjective.

Source: Holdren (1982)[19/]

energy purposes may result in problems such as the diversion of nutrients from agricultural lands (Figure 7). Eventually, however, extreme shortage of every sort of biomass fuel leads inevitably to reducing the number of cooked meals, and shortening the cooking time for individual meals, which in the end means more malnourishment and degraded lifestyles.

2. Conclusions

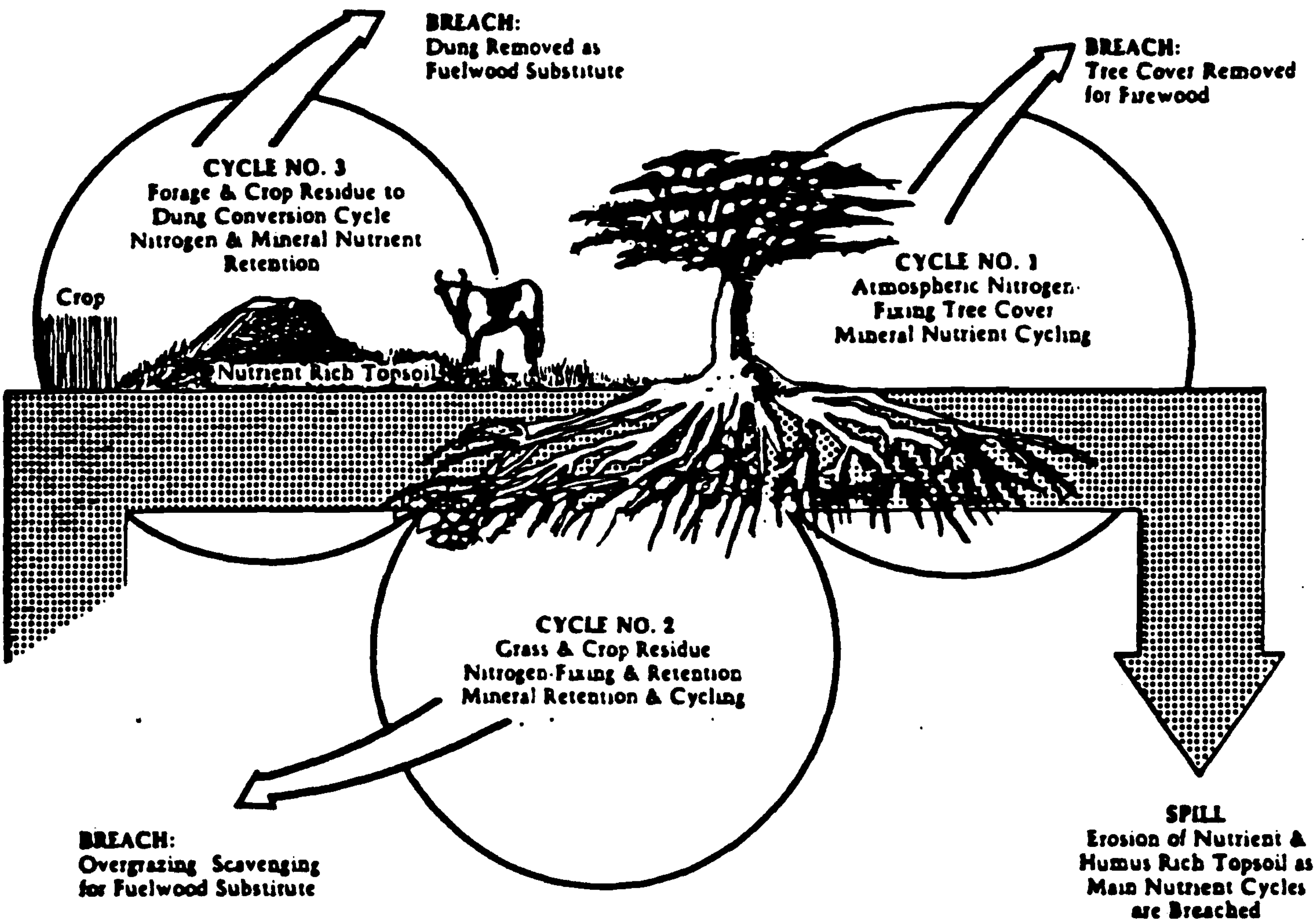
93. The resolution of the wood fuels crisis in developing countries is an essential pre-condition for their current survival (as a prerequisite to future development). On the one hand, energy needs both in the rural and urban areas must be met, either with additional wood, or other biomass or alternative energy sources. On the other hand, the disappearance of the trees and forests must be stopped and reversed, so that this valuable natural resource can sustainably supply fuel and other needs for the development process to proceed until wood is naturally superseded by cash economy fuels, such as kerosene, liquid propane gas or electricity.

94. During the last 10 years there has been a significant effort by governments and aid agencies to resolve the fuelwood crisis, but unfortunately mostly in vain. There is, however, a new opportunity to tackle the problem afresh. Given the completely different nature of the fuelwood crisis in the urban and the rural areas, different sets of policies are required for their resolution.

95. In urban areas where wood fuels are extensively used, most consumers purchase their requirements. Recently, as the price of wood fuels has been going up, poor families have been obliged to spend increasing proportions of their income on wood fuels (in Addis Ababa

FIGURE 6-7 b

Pattern of Deterioration in Ethiopian Agroecosystems



Source: Miller - 1986 28/

and Maputo families spend a third to a half of their incomes on wood). This also means that any fuel savings would translate into money saved.

96. Over the last 10 years a great deal of work has been done on the development of fuel-efficient stoves. Many acceptable ones have been developed, which can save 30-50 per cent on fuel. These, as well as aluminium cooking pots and pressure cookers, which also use much less fuel should be made available much more widely in urban areas.

97. Although charcoal is a more convenient, cleaner fuel and much reduces eye irritation and respiratory trouble experienced from wood smoke, conversion is presently a great wood waster. A major impact could be made on deforestation rates surrounding urban areas if more efficient charcoal conversion methods could be introduced. There are a large number of proven technologies available. The main problems seem to be social and political in character. Charcoal is usually made and marketed through informal networks of small-scale producers and suppliers using earth conversion pits where 100 kilogrammes of wood yield only 10-15 kilogrammes of charcoal. What is needed is their replacement with new style charcoal co-operatives or boards which could be involved in the planting of trees, selecting technologies and marketing the product made in brick or metal kilns, when 30 kilogrammes of charcoal per 100 kilogrammes of wood is readily obtained.

98. In addition to charcoal, there are other ways to transform wood into more efficient and practical fuels through chipping and briquetting. These should be promoted much more, particularly where forestry operations produce wood chips or sawdust.

99. Efficiency measures, however, will only buy time for wood supply enhancement measures to be introduced. The most important and urgent task is to improve the management of existing forests, including control of cutting and of encroachment.

100. Commercial forestry operations do not generally make sense for the provision of fuelwood in rural areas, but they do for urban and industrial needs. Commercial farm forestry, or on a larger scale dedicated energy plantations, can be viable enterprises. Greenbelts around large urban areas can be planted to provide wood fuels for the urban consumers. The additional environmental benefit of having a green zone around the city is not negligible either.

101. It is in these dedicated energy plantations that the high-efficiency charcoal kilns operate best. Given the high throughput of wood, their high cost can be justified. Some iron and steel industries in developing countries are based on charcoal produced from wood in such dedicated energy plantations. Unfortunately, most still depend on wood supplies from native forests, without caring about their reforestation.

102. Sometimes, especially in the initial stages, fiscal and tax incentives are necessary to get planting projects going. In a second stage these can be tied to success rates for tree growth, and can eventually be phased out. In urban areas, there are also relatively good prospects for increasing the supplies of alternative energy sources, such as electricity, liquid propane gas, kerosene and coal. A combination of the measures proposed in the section above may be able to increase wood fuel supplies in sustainable ways to urban and industrial consumers, that is consumers who can pay. The above strategies, however, will not be able to help most

rural people, particularly the poor, who collect most of their fuelwood needs. In their case, fuelwood is a "free good" until the last available tree is cut down. For the rural populations totally different strategies will be required.

103. Given the basic need for domestic fuel, and the low level of substitution possibilities, it seems, at least in the short and medium term, that the only way out of this problem is to treat fuelwood like food, and grow it as a subsistence crop. In the subsistence sectors, the need is to make fuelwood available locally where the demand is to be met, and not in distant regions and forests where transport costs make it too expensive to obtain.

104. Large, centrally organized, development bank or aid agency funded projects to increase fuelwood supplies for rural areas have on past experience, been shown to fail. Even if the projects themselves are not very expensive, the resulting fuelwood is always more expensive than that which rural people can afford. Again, recent experience shows that better results can be obtained by decentralized, small-scale action through NGOs and other local organizations, where the planting and growing of trees is taken care of by the people themselves.

105. The best way to do this is by employing various agro-forestry techniques, some of which have, in fact, been used for generations. These allow the growing of a few trees around the house, in the fields or in grazing areas, in combination with food and fodder plants. The combined food/fuel/fodder output is higher than if the

land were used only for one or the other activity. In places, where local community organization is strong, the potential of village or community level social forestry programmes is large. India has been one example, where small initial help from a central government can start off very successful projects.

106. In most rural areas, however, simply growing more trees does not necessarily solve the problem. Often the picture is further complicated by complex socio-political factors. In many areas, in spite of a relative abundance of trees the availability of wood fuels is very low. One finds that the reasons tend to include problems like access to and ownership of trees, or the role of women in society.[29/, 30/, 31/, 32/] Suitable solutions will have to be worked out for such local problems by the communities concerned.

107. One message which comes through is that governments, aid and development organizations who want to help the fuelwood situation in developing countries have to make a much more intensive effort to understand the role fuelwood plays in rural areas, and the social relations governing its production and use. The particular problem of women and the fuelwood crisis needs much more attention than hitherto. In fact, women are the main actors involved in the collection and use of fuelwood. Consequently, development projects related to fuelwood must have women as the main targets.

(Rec 6.20)

Governments in countries where wood fuels are traditionally used should

* take urgent measures to estimate the geographic distribution and current status of standing stocks and annual yields of their national wood resources;

* assess where and how far wood fuel gathering is less than, or in excess of, annual regrowth and where the latter occurs, evaluate the rate of local wood stock depletion;

* carry out the above tasks as part of the work of compiling the National Renewable Energy Inventory (Rec 6.14 above).

(Rec 6.21)

Where serious deficits are discovered or anticipated up to within the next 15 years, Governments should

* plan a series of measures for using wood fuels more efficiently, thus extending the period of their availability by demand reduction strategies designed to "buy time" for policies of supply enhancement of wood and other fuels;

* develop policies of supply enhancement.

Demand reduction strategies will involve

** providing alternative fuels, particularly in towns (electricity, liquid propane gas, kerosene, coal, biogas from urban waste and affordable end-use devices to match, e.g. inexpensive electric hot plates, small kerosene burners and coal stoves);

** encouraging the formation of charcoal corporations (private or public sector) using improved, efficient brick or metal conversion kilns;

** developing policies designed to make available affordable, "improved-efficiency" charcoal and wood stoves, e.g. by artisan training schemes for new designs; mass-production methods and small, low-interest loan schemes for their purchase. This programme will also have to supply inexpensive lighting for after dark because improved wood-stoves enclose the fire and exclude firelight;

** promoting publicity campaigns about domestic heat management, e.g. cooking times for various foods; pre-soaking hard foods (pulses, grains) before cooking; heat maintenance using hay-boxes, vacuum jars, pressure cookers, etc.; how best to store cooked foods.

Supply enhancement policies will involve

** encouraging ways of using biomass that is normally wasted, e.g. thinnings and waste-wood from remote private and state forests transported to human settlements by producer-gas trucks running on charcoal made from waste wood and thus avoiding prohibitive fuel costs; chipping and/or briquetting twigs, awkward angular woody material, leafy shoots and appropriate crop residues;

** vigorously promoting agroforestry practices among peasant farmers; designed to grow food and fuel together without affecting food yields;

** encouraging "do it yourself" grassroots tree and shrub planting schemes (non-commercial woody species on fallow land, in hedgerows, along paths or in waste places)

** encouraging communal wood lots where socially appropriate;

** stimulating the development of peri-urban forest belts among consortia of landowners (public authority or private sector);

** encouraging small seedling nurseries.

(Rec 6.22)

Governments should

* promote information and advice on handling woodfuel problems through their energy centres (Rec 6.10) and extensions services;

* encourage national coverage and discussion of these problems and the most appropriate solutions, via mass media campaigns.

(Rec 6.23)

Development Aid Agencies should

* continue to provide valuable assistance to governments in support of demand reduction strategies (improved cook-stoves and charcoal kilns) and supply enhancement policies ("grassroots" agroforestry and tree or shrub planing schemes, chipping and briquetting trials, gasifier projects).

(Rec 6.24)

Banks and finance corporations should

* encourage the formation of consortia for charcoal production from peri-urban woodland belts and other suitable plantations

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(Rec 6.25)

NGOs,(Church groups, women's organizations, community service agencies should

* work with local people to assist them in the "grassroots" projects described above;

* assist with the paperwork needed to connect local efforts to government on aid-agency schemes.

VII. FOSSIL FUELS: POLLUTE AND PAY

108. Although all energy systems have environmental impacts, high levels of fossil fuel consumption are of special concern. They pose three closely interrelated atmospheric pollution problems inimical to sustainable development: urban industrial air pollution[33/, 34/, 35/, 36/], acidification of the environment[37/, 38/, 39/, 40/] and climatic change[12/, 41/, 42/] Some of the

richer industrialized countries may possess the economic and social resilience and institutional capacity needed to cope with these threats. Most developing countries, however, and especially those who spend a proportionately large part of their national income on energy imports (See Table 3) do not.

1. Reducing Urban-Industrial Air Pollution

109. During the past three decades of rapid growth, urban air pollution potential has increased dramatically, more or less in pace with fossil fuel consumption for space heating (and cooling), automobile transport, industrial activities and electricity generation. Beginning in the late 1960s, a growing awareness of the effects of polluted air on human health, property and the environment in urban and industrial areas created a demand for action. Several industrialized countries responded, enacting control measures of various kinds. Most imposed standards that resulted in the development of curative measures, including add-on technologies. Some imposed liability and required compensation for damage, especially damage to human health. While expensive, this react-and-cure approach led, in time, to greatly reduced emissions of some of the principal pollutants and cleaner air over many cities.

110. Several industrialized countries, however, and virtually all developing countries failed to share in this experience. Instead, they witnessed a steady deterioration in the quality of their air with all its attendant effects. Air pollution has reached serious levels in most major Third World cities, often far exceeding the worst cases of the 1950s in industrialized countries.

111. The fossil-fuel emissions of principal concern include sulphur dioxide, nitrogen oxides, carbon monoxide, various volatile organic compounds (VOCs), fly ash and other suspended particulates. They are potentially injurious to human health, and may damage body tissue and the nervous system, bringing increased respiratory complaints, some potentially fatal. They can cause higher morbidity and mortality in segments of the population, specially sensitive to lung trouble. Transformed into acid in the air, they damage vegetation, corrode buildings, metallic structures and vehicles, causing billions of US dollars in damage annually, and may eventually contribute to land and water pollution. Excepting a few western industrialized countries, studies of the social and economic costs that these effects impose on the economy of communities and nations are non-existent, or unavailable. What few studies are available, however, demonstrate that they are potentially enormous, and in most of the world they are growing rapidly.

112. Today, the fossil-fuel sources of air pollution are avoidable or largely controllable at a cost to the community and nation that is now widely believed to be usually less than the damage costs that will otherwise be incurred. In a high energy future, however, both prevention and control would be extremely expensive, particularly in developing countries. The most cost-effective means of prevention available, are those implicit in a low energy future. Moreover, these and other means would reinforce those needed to prevent and control another major fossil fuel problem closely related to urban-industrial air pollution: acidification of the environment.

2. Preventing Acidification

113. The measures taken by many industrialized countries in the 1970s to control urban and industrial air pollution (high stacks, for example) greatly improved the quality of the air in the cities concerned. While reducing local human exposure however, it quite unintentionally increased the problem to soils and communities of plants and animals elsewhere. This was manifest in a rapid rise in transboundary air pollution in Europe and North America and an increasing acidification of the environment. In consequence, the perception of atmospheric pollution has widened from that of a local urban-industrial problem involving the health of human communities, to that of a much more complex problem involving both people and ecosystems regionally over many hundreds of kilometres.

114. During long distance transport in the atmosphere, emissions of sulphur oxide, nitrogen oxide and volatile hydrocarbons are transformed into sulphuric and nitric acids, ammonia salts and ozone. They fall to the ground, sometimes many hundreds of kilometres from their point of emission, as dry particles or in rain, snow, frost, fog and dew.

115. Cryptically accumulating over the decades, damage to the environment first became evident in Scandinavia in the 1960s. Since then, the recognition of damage has mounted at an accelerating pace. Several thousand lakes in Europe and some in North America have registered a steady increase in acidity levels to the point where they no longer support their natural fish populations. The same acids enter the soil and ground water, increasing

the corrosion of drinking water piping in Scandinavia, and concern has been expressed that they may possibly liberate potentially toxic metals and pose risks to human health.

116. The circumstantial evidence indicating the urgent need for action on the sources of acid rain is mounting with a rapidity that overwhelms the time-frames needed by scientists and governments to assess it scientifically.[37/,/38/] Up to now, the greatest damage has been reported over Central Europe, which is currently receiving more than one gram of sulphur on every square metre of ground each year (Figure 4). There was little evidence of tree damage in Europe in 1970. In 1982, the Federal Republic of Germany reported visible damage in 8 per cent of its sample of forest plots nationwide; in 1983, this rose to to 34 per cent and to 50 per cent in 1985.[40/, 28/, 43/] Sweden reported light to moderate damage in 30 per cent of its forests; and various reports from other countries in Eastern and Western Europe are extremely disquieting. So far an estimated 5-6 per cent of all European forest land is affected.

117. The evidence is not all in, but many reports show soils in parts of Europe becoming acid throughout the tree rooting layers, particularly the nutrient-poor soils of Southern Sweden.[11/,41/] The acidity is frequently so high that aluminium comes into solution as a mobile element, toxic in very low concentrations to plant roots. The precise physiological mechanism of tree death is still not clear. But so far, the balance of evidence seems to indicate that it is likely to be caused by acid soils releasing enough mobile aluminium to cause root damage and by direct damage to conifer needles from the

interaction of the acidic and oxidizing pollutants mentioned above. Root and leaf damage appear to co-act, both affecting the ability of the trees to take up water from the soil and retain it in the foliage, so that they become particularly vulnerable to dry spells.

118. If this is true, we may have reached a trip-over point in Europe. We may be witnessing an immense, regional acid-base chemical titration with potentially disastrous results being signalled by widespread tree damage and death, in effect, a kind of "environmental litmus paper", indicating a change to irreversible acidification whose remedial costs are beyond economic reach.[40/, 42/] Comparatively speaking, forest death on a regional scale would be socially and economically trivial compared with such consequences as erosion, soil slippage and land slides, siltation, flooding of farmlands and towns. No single pollutant control strategy is likely to be effective in dealing with forest decline - it will take nothing less than a total integrated mix of strategies and technologies, tailored for each region, significantly to improve air quality.

119. Evidence of acidification in the newly industrializing countries of Asia, Africa and Latin America is beginning to emerge. China, Korea and Japan seem particularly vulnerable, given industrialization trends in the former two, as do Venezuela, Colombia, Ecuador and Brazil. So little is known about the likely environmental loading of sulphur and nitrogen and about the acid neutralizing capacity of tropical lakes and forest soils that, at a minimum, a comprehensive programme of investigation should be formulated without delay.[39/]

120. In the United States, where a great deal of emission control has already been successfully achieved, it has been estimated that reducing the remaining sulphur dioxide emissions by half from existing sources would cost an additional US$ 3-4 billion a year, increasing present electricity rates by 2-3 per cent. If nitrogen oxides were figured in, the additional costs might be as high as US$ 6 billion a year.44/ Other estimates would add up to a doubling of this figure. Likewise, estimates of the annual costs of securing a reduction in the remaining sulphur emissions in the countries of the Commission of European Communities of 55 to 65 per cent between 1980 and 2000 range from US$4.6 to 6.7 billion (1982 $) per year. Controls on stationary boilers to reduce nitrogen levels by only 10 per cent per year by 2000 range between US$ 0.1 and 0.4 billion (1982 $).45/ While high in absolute terms, even in countries whose energy systems depend heavily on coal-based thermal power, these figures translate into a one time increase of about 6 per cent in the price of electrical power to the consumer.

121. Estimates of damage costs in Europe are much less reliable and, given the trends noted above, necessarily very conservative. Nonetheless, studies place damage costs due to material and fish losses alone at US$ 3.0 billion a year; while damage to crops, forests and health are estimated to exceed US$ 10.0 billion per year. But again, the evidence is not yet in. Recent Japanese laboratory studies35/ indicate that air pollution and acid rain can reduce some wheat and rice crop production, perhaps by as much as 30 per cent.

122. Modern equipment and technologies such as powdered coal-liquid mixtures, fluidized bed combustion, low NO_x burners, gasification and secondary smoke condensers can remove sulphur, nitrogen and also many other troublesome

pollutants quite adequately and cost-effectively, either before, during or after combustion. But the strategies implicit in the low energy scenario offer the most cost-effective means of reducing future levels of acidification in industrializing and developing countries alike. And they would also buy time for the nations of the world to assess and prepare for the implications of global climatic change.

3. Managing Climatic Change

123. Upon combustion, fossil fuels also emit the gas carbon dioxide, which accumulates in the atmosphere. The pre-industrial concentration was circa 280 parts of carbon dioxide per million parts of air by volume (ppmv). This concentration reached 340 in 1980 and is expected to double (to 560) between the middle and the end of the next century. No proven technologies exist to control the emissions of carbon dioxide. Other gases are also accumulating in the atmosphere, principally, chlorofluorocarbons (used as aerosol propellants in spray cans, for the foaming of plastics and in heat-pumps and refrigerators as a heat transfer medium); methane (emitted from wet, reducing soils, e.g. marshes, rice-paddies, or from herbivores, or the earth's surface, especially where oil or gas is exploited); nitrous oxide (derived from cold, moist soils and the breakdown of nitrogenous fertilizers); and ozone (generated by industry, internal combustion engines and photochemical oxidations in the atmosphere). Apart from these, there are at least a further 28 gases released by human activity in trace amounts, any of which could be significant in future.

124. After reviewing the latest evidence in October 1985, scientists from 29 industrialized and developing countries concluded that climate change must be considered a "plausible and serious probability". 12/ They further concluded that: "Many important economic and social decisions are being made today on ... major water resource management activities such as irrigation and hydropower; drought relief; agricultural land use; structural designs and coastal engineering projects; and energy planning - all based on the assumption that past climatic data, without modification, are a reliable guide to the future. This is no longer a good assumption since the increasing concentrations of greenhouse gases are expected to cause a significant warming of the global climate in the next century. It is a matter of urgency to refine estimates of future climate conditions to improve these decisions." They estimated that if present trends continue, the combined concentration of CO_2 and other greenhouse gases in the atmosphere would be radiatively equivalent to a doubling of CO_2 from pre-industrial levels, possibly as early as the 2030s, and could lead to a rise in global mean temperatures "greater than any in man's history". Current modelling studies and "experiments" show a rise in globally averaged surface temperatures, for an effective CO_2 doubling, of somewhere between 1.5°C and 4.5°C, with the warming becoming more pronounced at higher latitudes (during winter) than at the equator. This temperature rise may take some decades to reach full equilibrium with the increased trace-gas concentrations.

125. The great concern, of course, is "that a global warming of 1.5 - 4.5°C would lead the sea level to rise from 25 - 140 cm". A rise in the upper part of this

range would inundate low lying coastal cities and agricultural areas, and many countries could expect their economic, social and political structures to be severely hit.

126. Unless pre-planned adaptation strategies were readily available globally, local disasters could escalate swiftly into international crisis. This would be accentuated by the effects of changing climate and water-regimes on inland crops, forests and ecosystems. Although knowledge about these effects cannot be certain until they occur, experts believe that crop boundaries will move to higher latitudes. The effects of warmer oceans or marine ecosystems on fisheries and food chains are also virtually unknown.

4. Conclusions

127. Nobody knows how communities and nations will respond to these situations as they evolve. Governments, however, and the world community are in a position to anticipate them and to take certain measures to abate emissions and so avoid these problems or at least reduce their impact. In the case of climatic change, this latter strategy would buy time to facilitate adaptation to the consequences.

128. We seem to be entering an era where sooner or later nations will have to formulate and agree upon long-term policies for all industrial- and energy-atmosphere interactions affecting sustainable development and influencing the radiation balance on earth. This will not happen soon, but given the complexities of international negotiations on such issues and the time lags involved it is urgent that the process start now.

129. What is needed for these issues, in fact, marked as they are by varying degrees of uncertainty, is a three-track strategy combining:

* improved monitoring and assessment of the evolving phenomena;

* increased research to improve our knowledge about the origins, mechanisms and effects of the phenomena;

* the development and implementation of new or modified clusters of economic, finance, trade and sectoral policies. These latter policies should be such as to prevent or reduce the avoidable and destructive impacts of these phenomena on human health, resources and ecosystems, especially those which involve a high risk of irreversibility and transgenerational impacts.

130. No nation worldwide has either the political legitimacy or the economic power to implement this three track strategy. If it is to be started up, the only body likely to be successful is the United Nations. However, the consensus statement issued at Villach [12/] recommended such a strategy for climate change to be promoted by governments and the scientific community via the World Meteorological Organization, the United Nations Environment Programme and the International Council of Scientific Unions. The Villach Statement further recommended that if deemed necessary, consideration be given to the need for a global convention.

131. While this strategy is being developed, more immediate policy measures can and should be adopted. The most urgent, as mentioned earlier, is a careful consideration of how to achieve an effective arrangement to reduce the wild fluctuations in world energy prices and maintain them at levels which will continue the

steady gains in energy efficiency and a shift in the energy mix towards more renewables. There is detailed prima facie evidence that carbon dioxide output globally could be halved by energy efficiency measures over the next 50 years or so without any reduction of the tempo of GDP growth.[4/, 5/] And, as noted earlier, these measures would also serve to reduce other emissions and thus reduce acidification and urban-industrial air pollution. In addition, they would also improve balances of payments, reduce debt burdens and provide rich sources of revenues for countries to improve sound fiscal management.

132. Many other mutually reinforcing measures should also be entertained. Measures deliberately to switch the fossil fuel mix, are one example. The current global energy mix (per cent) is oil 41; coal 24; gas 17; other 18. One TWyr of energy from oil or coal or gas liberates 0.62; 0.75; 0.43 gigatons of carbon respectively. Consequently, gaseous fuels should be promoted at the expense of solid ones. As far as possible, gaseous fuels should be the fuels of choice for cooking and other domestic uses, in particular, since it is generally more difficult to implement pollution control at the domestic level.

133. Apart from fuel cleaning and fuel switching, financial mechanisms should be established that build the external costs of different energy sources into their prices. Strengthened economic incentives and disincentives favouring environmentally attractive energy investments are needed; as are emission limits, with licences to reflect them; and flexible trading in such licences; and improved regulatory measures.

134. Gases other than carbon dioxide are thought to be responsible for about one third of present global warming and it is estimated that they will cause about half the problem around 2030. Two chlorofluoro- carbons alone (trichlorofluoromethane, CCl_3F:F-11 and dichlorodifluoromethane, CCl_2F_2:F_{12}) are thought to be responsible for circa 20 per cent of the present day temperature rise.[46/] This percentage, it is believed, may increase to 50 by the turn of the century. A roughly four-fold increase in chlorofluorocarbons is expected before 2050 at present rates of emission.[46/] Apart from the climate effect these will induce, it is estimated that they will cause a reduction in the stratospheric ozone shield of 10-30 per cent, thus allowing greater ultraviolet radiation to reach the earth's surface.

135. These additional data indicate that the chemical industry should make every effort to find a replacement for the chlorofluorocarbons used in refrigerators and heat pumps and for foaming plastics. In the case of spray cans, on the other hand, since replacement gases already exist, the use of chlorofluorocarbons should be banned everywhere, and as soon as possible.

136. Much of the uncertainty concerning the future global energy path could be cleared away if negotiated agreements could set "ceiling" levels for the quantities of the principal transboundary air pollutants, including carbon dioxide and work backward to map out exactly what energy strategies would be needed in future to peg them below these ceilings. The available range of strategies can provide ample room for national priorities and for the energy supply conditions that are unique to each nation, but a lot of policy development work is needed to

obtain them. This should proceed hand in hand with accelerated research to reduce remaining scientific uncertainties. What is needed urgently is a concerted act of political will.

(Rec 6.26)

Energy and Planetary Limits

In view of the threats to planetary stability and societal survival, by the turn of the 21st century, nations should have formulated and agreed upon management policies for the release of all environmentally reactive chemicals into the atmosphere by human activities, particularly those that can interact in the atmosphere and stratosphere to influence the radiation balance on earth.

Governments should, through the Security Council, and on the advice of the proposed World Council on Sustainable Development or similar agency with an equivalent global remit,

* establish a Working Group to initiate discussions (negotiations) on a convention concerning the prevention or controlled release of environmentally reactive chemicals into the atmosphere, particularly those that induce climate change or that pose serious threats to health and to essential life support systems.

If a convention on chemical containment policies cannot be negotiated, agreed or implemented adequately within the next 15 years, the Working Group should

* propose means to establish contingency strategies and plans for adaptation to climatic change, including

  ** altered regional water-regimes
  ** major shifts in agriculturally productive zones;
  ** rising sea levels, inducing flooding of low-lying rural and urban areas, massive shifts in populations, new territorial boundaries, etc..

In either case, the Security Council should encourage WMO, UNEP, WHO, ICSU and other relevant international and national bodies to

* co-ordinate and accelerate their programmes to develop a carefully integrated strategy of research, monitoring and assessment of the likely impacts on climate, health and environment of all environmentally reactive chemicals released into the atmosphere in significantly active quantities (including those emitted from energy use);

* make special efforts to estimate the costs of abatement and adaptation strategies compared with the costs of doing nothing to contain them or their impacts.

(Rec. 6.27)

Governments should

* support research under the "World Climate Programme" and other related activities of WMO to obtain a clearer understanding of the chemically reactive dynamics in the atmosphere and stratosphere of substances released by Man and from natural causes.

(Rec 6.28)

Governments, through ECOSOC, should

* support the assessment work of WMO; UNEP and ICSU in their "Advisory Group on Greenhouse Gases" and participate collaboratively:

  ** in the examination, analysis and development of policies to abate radiatively active trace substances released to the atmosphere;

  ** policy development designed to adapt societally to the effects of climatic change.

(Rec 6.29)

Regional Agencies in the U.N. system such as UNECE - or other appropriate regional bodies where they exist - should

* propose national and regional air-quality goals and objectives; allowable national atmospheric loadings for a region employing the "bubble" principle; and related emission criteria or standards;

* develop internationally acceptable technical guidelines for monitoring urban air pollutants;

Where no suitable regional body exists, careful consideration should be given to creating one or extending the remit of existing regional groups such as SADCC, ASEAN to perform this task.

(Rec 6.30)

Governments in many regions (e.g. China, Japan, Korea) could gain significantly from transboundary air pollution agreements to prevent air pollution and acid rain. Through these regional agencies, Governments should

* develop and implement agreements, at the appropriate regional scale, to prevent air pollution and acid rain and to reinforce measures to reduce emissions of CO_2 into the atmosphere.

* adapt these guidelines for national use to implement a monitoring system for urban air pollution in major towns and calculate abatement costs;

(Rec 6.31)

Where actual or potential threats from atmospherically transported acidic and oxidizing substances are believed to exist, Governments should

* prepare national maps of naturally occurring, base-deficient or weakly buffered soils (sensitive areas)

* monitor and assess forest damage annually and soil impoverishment every five years according to regionally agreed protocols and

* publish the data, assessments and results .

(Rec 6.32)

Governments should

* support ongoing transboundary (inter-state) pollutant monitoring being carried out by agencies in their region, such as EMEP of UNECE, and

* support systems optimization studies designed to limit acidification damage at minimal overall cost to the Region.

Where no appropriate regional agency exists, neighbouring governments may wish to

* create one or extend the activities of any suitable regional body,

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(Rec 6.33)

Acidic and oxidizing substances transported in the atmosphere are likely to increase in tropical and sub-tropical countries as a result of urban industrial growth. Governments, through ECOSOC, should

* encourage UNEP, (WHO, WMO) and ICSU, and multilateral and bilateral development assistance agencies to undertake studies of their effects on human health, soils, vegetation and the environment

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(Rec 6.34)

Multilateral and bilateral development assistance agencies and development banks, as a condition of assistance, should encourage governments to

* require that best practical technology be used when planning permission is being sought by industries and energy utilities to build new or extend existing facilities. Such plans should

* provide for cleaner combustion and conversion of fossil fuels especially coal.

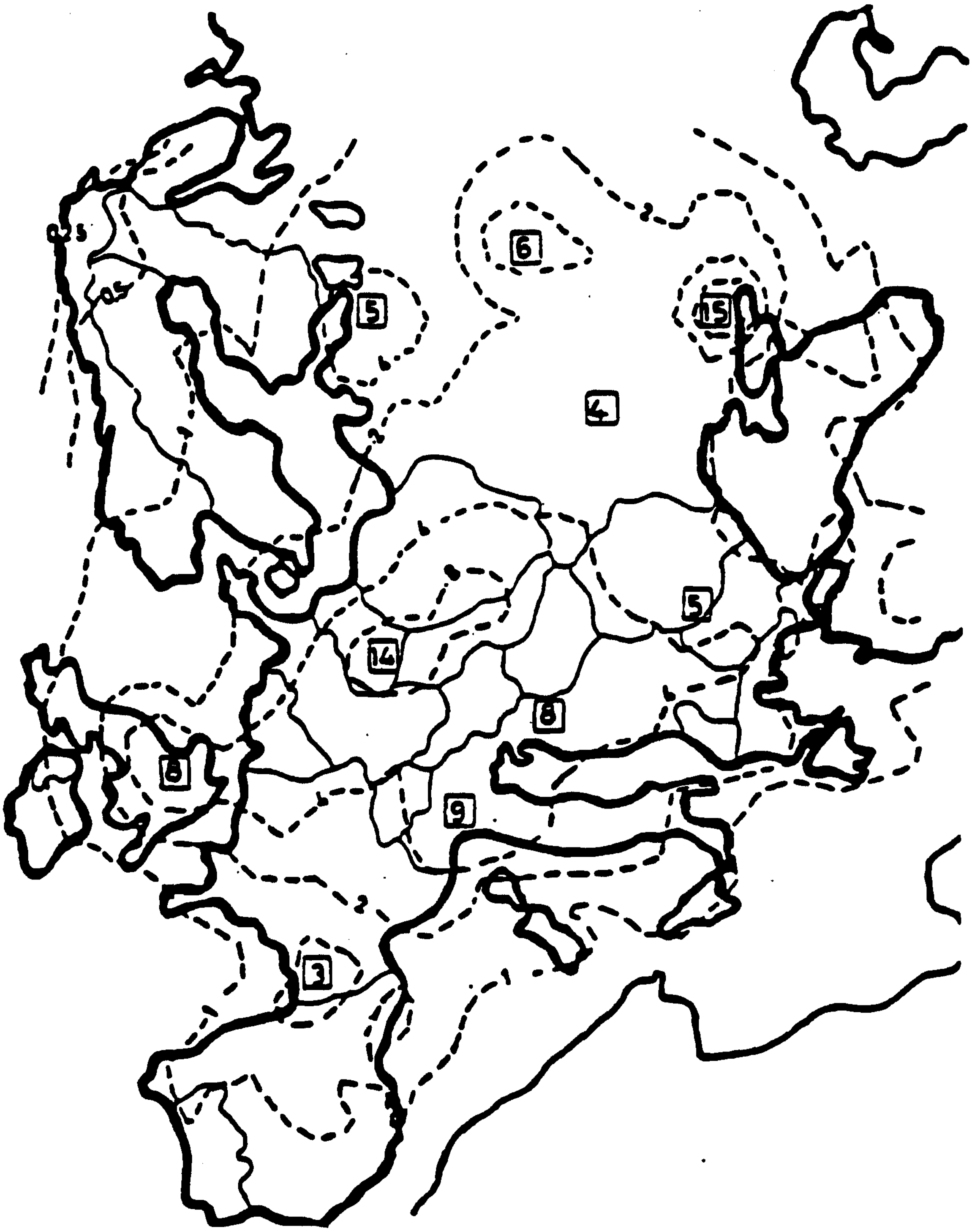
(Rec 6.35)

Governments should

* ratify the existing ozone convention and develop protocols for the limitation of chlorofluorocarbon production, and systematic monitoring and reporting of implementation.

FIGURE 6-4

Acid Deposition on Europe



Note : Isolines of Average Annual Total Deposition of Sulphur, expressed as grams of sulphur per square meter of ground per year, based on the period October 1978 - September 1982. Maxima are shown as boxed numbers.

Source: adapted from EMEP/MSC-W Report 1/85[29]

VIII. NUCLEAR ENERGY: THE UNSOLVED PROBLEM

1. The Nuclear Dilemma

137. Although nuclear energy has more than quadrupled worldwide in the last decade, its steady growth of around 15 per cent annually has been less than was expected when it was first used to generate electricity during the 1950s, a time when there was over-optimism that nuclear would solve all our energy problems. Today, nuclear reactors supply about 15 per cent of all the electricity generated, which itself constitutes around 15 per cent of global primary energy supply. Roughly one quarter of all countries worldwide have reactors. In 1986, there were 366 working and a further 140 planned[47/] with 10 governments possessing circa 90 per cent of all installed capacity (>5 GW(e)). Of these there are 8 with a total capacity of>9 GW(e) which provided the following percentages of electric power in 1985: France 65; Sweden 42; FRG 31; Japan 23; U.K. 19; USA 16; Canada 13; USSR 10. In Western Europe and North America, which today have almost 75 per cent of current world capacity, nuclear provides about one third of the energy that was forecast for it ten years ago. Apart from France, Japan, USSR and several other countries in Eastern Europe who have decided to continue with their nuclear programmes, ordering construction and licensing prospects for new reactors in many other countries look decidedly poor. In fact, between 1972 and 1986, earlier global projections of estimated capacity for the year 2000 have been revised downwards by nearly a factor of seven.

138. Why has nuclear energy growth been a disappointment up to now, particularly in the United States, where in the last ten years or so, around US$ 18 billion invested in over 100 planned reactors has been virtually shelved? One factor is that the electricity demand projections made at that time, both in the United States and Europe, have today proved over-optimistic and remain unrealized. But apart from this, particularly in the U.S.A., there have been serious construction delays and consequently, extremely heavy cost increases, often tripling or quadrupling to circa US $ 3000 per kilowatt of installed capacity during the 1980s. This has been compounded by breakdowns and running difficulties with higher than expected "down-time" on many reactors. By contrast, in France for example, strongly centralized control of state-owned companies has got installations built on target, or be it with certain companies ending up with extremely large debts.

139. But these cost, construction and control difficulties have been eclipsed by a fairly widely held grassroots anxiety about nuclear safety among a sector of the public in several industrialized countries. This anxiety has expressed itself in anti-nuclear campaigns over nuclear risks which use the full range of political activism from anti-nuclear advertising right through to public demonstrations and riotous behaviour. These activities have added to delays in licensing and over-runs in costs and they have been of deep concern to the democratic governments in Europe and North America who need to get nuclear voted in. All this has meant that over the last decade, nuclear energy has become an important and contentious political issue.

140. Thus, in several countries, nuclear power agencies have lost the public confidence. Regaining it will take time and a much more open approach to information disclosure about all sectors of the nuclear fuel cycle. It will also require a transparently demonstrated record of safe operation, a resolution of outstanding questions concerning the decommissioning of nuclear reactors and radioactive waste management, including sites for the permanent disposal of high-level radioactive wastes. The lack of a clear separation of civilian and military nuclear activities in those countries where there is full technical access to the complete fuel cycle is also at present an important cause for public anxiety about making nuclear energy societally tolerable.

141. Nuclear safety returned dramatically to the headlines following the Harrisburg (Three Mile Island, USA) and the Chernobyl (USSR) accidents. The post-accident analyses have shown that in both cases human error was the original and most likely major cause. The best available estimates of a reactor core melting through a pressure vessel, or the most serious category of a release through containment failure have placed the risks at once every 20,000 and every 1,000,000 reactor years respectively.[48/] These were arrived at following highly complex statistical calculations on western style light-water reactors, estimating probabilities of component failures, but paid less attention to the "knock-on" effects of the failure in one component increasing the likelihood of failure in a related or linked component. More importantly, human error problems are well-nigh impossible to handle probabilistically. Harrisburg and Chernobyl occurred after circa 2000 and circa 4000 reactor years respectively. However, a recent study which allowed for their incidence has proposed that there is a 95 per cent probability of a major core-damaging accident within the

next 20 years, i.e. within 10,000 reactor years, given the number of reactors expected to be operating up to the year 2000.[49/] This reinforces the Commission's view that for those governments developing nuclear energy a new generation of "fail-safe" and operationally fool-proof reactors is needed, in which the risk of catastrophic accidents would be eliminated. Various designs of fail-safe reactors have been developed and in the future they should be the reactors of choice.

NOTE: Paragraph on the quality of environmental and/or political consequences of nuclear risk to be inserted after consultation with Dr Hauff

142. Since Chernobyl, several governments, notably the U.S.S.R., China, France, Japan, Poland and the U.K. have maintained or re-affirmed their pro-nuclear policy. Others (Denmark, Italy, the Netherlands, Australia, Greece, Sweden, Switzerland, Yugoslavia) are either maintaining or re-investigating the anti-nuclear arguments or have introduced legislation tying any further growth of nuclear energy and export/import of nuclear reactor technology to a satisfactory solution of the problem of disposal of radioactive wastes. This has intensified the search for environmentally acceptable forms of management of these wastes, and has brought some nations closer to solutions for their final disposal. As a result, the technology of disposing of even the long-lived, high-level wastes in environmentally acceptable ways has now reached the stage of technical feasibility, on paper at least, in a number of nations.[49/, 50/] Experimental follow-through has been made difficult, at least in part due to substantial public opposition from many towns and districts to the designation of their lands as a potential repository. This "not-in-my- backyard" syndrome will have to be overcome before "technical feasibility" can be translated into actual "disposal" of the wastes.

143. Although it is frequently suggested that waste disposal should be achieved as a result of international co-operation, there are a number of difficulties with this idea. International co-operation under binding conditions and strict supervision, probably through an authority accountable to some clearly neutral body would seem imperative for the siting and operation of any international repositories either in the international commons or on national territory. Problems of agreeing on the location and supervision of such repositories seem so great as to make them unlikely to start up before a number of purely national repositories are brought into operation.

2. Conclusions

144. The Commission is satisfied that the potential for generating energy from nuclear sources is so important for future development in an environmentally benign manner that ways must be found to achieve it with a level of safety which is universally acknowledged to be societally acceptable. Moreover, the Commission believes that although this is not being done at present, because of the problems referred to in sections 144.1-3 below, there is already enough technical and other evidence demonstrating that this can be done in future, given general agreement on certain codes of practice for the operation of the nuclear fuel cycle. Notwithstanding the longer-term confidence in nuclear energy expressed above, the Commission expresses deep concern that at the present time the use of nuclear energy poses problems which are not yet adequately solved.

114.1 Mankind had been assured by "experts" that nuclear accidents such as those of Harrisburg and Chernobyl were of such low probability that we need not be worried about them. That reassurance was demonstrably wrong. The probability may be low but it is not insignificant. Such a catastrophe is jeopardizing the present generation and poses a serious health risk to future generations.

144.2 Although an institutional separation has been established between the military and civilian uses of nuclear energy through the Non-Proliferation Treaty, for countries with full access to the complete fuel cycle of nuclear energy, no technical separation really exists. The worldwide civilian use of nuclear energy is therefore a real danger to the non-proliferation of nuclear weapons and thus a threat to peace.

144.3 In no country of the world has the problem of how to arrange for the safe disposal of high-level nuclear waste really been solved. The same is true for the decommissioning and dismantling of nuclear power plants when they are running out of use. In addition, nobody knows the costs. Both these problems create a growing burden for future generations.

145. For the above reasons, the Commission believes that the generation of nuclear energy as currently practised is no longer acceptable today, and in the long run, only justifiable if there is a solid solution for the above unsolved problems of nuclear energy. However, the Commission wishes to reaffirm its conviction that, with the appropriate political commitment and support, these problems can be satisfactorily solved in future.

146. It is recommended that the United Nations should organize an international conference which should assess nuclear energy in all its aspects (including the alternatives) in order to find a safe energy path for the world.

147. In any case, the Commission's mandate of interdependent anticipation and prevention requires that the international dimensions of a nuclear plant be recognized from the very beginning in its design, siting and operation. Negotiations on a more comprehensive internationally binding convention on the peaceful uses of nuclear energy should commence immediately with the United Nations conference mentioned above forming an integral part of the process. Such a convention should give careful consideration to the following items for inclusion in its recommendations:

* an obligation by member states to notify in advance and to co-ordinate with neighbouring states the siting of all future nuclear installations, including reactors, reprocessing plants and radioactive waste storage and repository locations; there should be an international agreement on matters of site selection criteria, safety standards, releases into the environment and compensation in the event of a catastrophic accident;

* an obligation on all signatories to communicate routinely operational details such as fuel loading timetables;

* an obligation by all signatories not only to notify automatically all neighbouring states of all nuclear accidents on their territory, but also an obligation to provide information concerning the quantity and types of radioactive materials released into the environment both during normal operations and as a result of accidental releases;

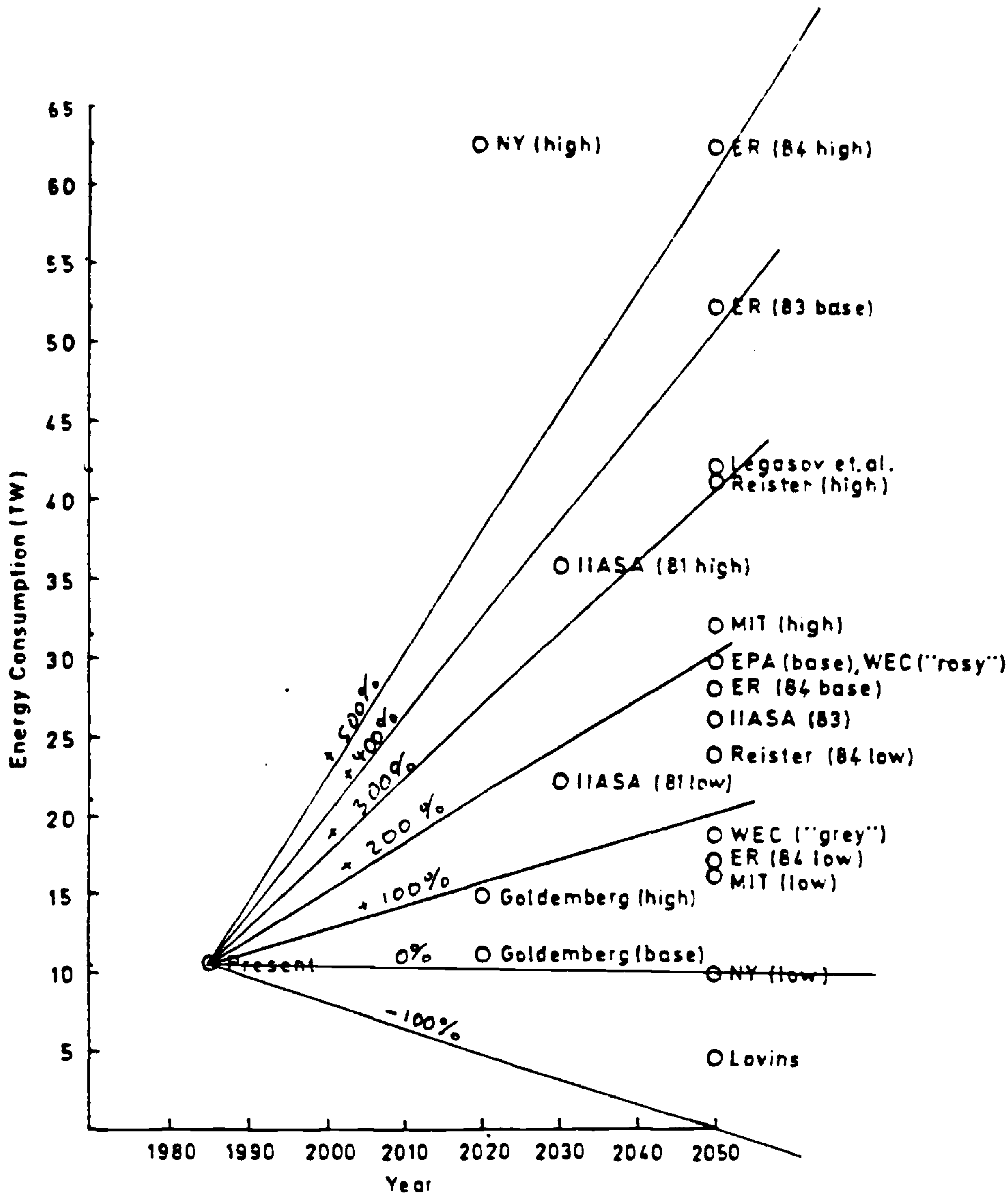
* the advance preparation of regional contingency plans to deal with nuclear accidents, and the obligation to co-ordinate clean-up efforts at a regional level.

* the progressive adoption of mutually agreeable reactor safety and radiological protection criteria.

148. Chernobyl has also highlighted the need to strengthen the regulatory functions of IAEA and to separate them from the promotional role of the agency. At the national level, during the past two decades, several countries have moved in this direction, separating nuclear power development, manufacturing and sales from regulation of the nuclear industry. Similar steps should be taken at the international level. This would require agreement to revise the statutes of the IAEA, however, and that would undoubtedly take many years, if it could be achieved at all. In the meantime, until such agreement can be realized, the IAEA should consider a separation of its functions into two major branches, with the promotion of nuclear power institutionally divorced from the promotion and regulation of nuclear safety, safeguards and environmentally sound nuclear waste disposal.

FIGURE 6-3

Projections of Primary Energy Consumption in the Future



Note: The circles represent actual projections, while the lines show percentage variation from the 1985 (actual) level, in units of 100 per cent.

Source: After Keepin et al - 1985[6]